November 2000

# MALHEUR RIVER BASIN COOPERATIVE BULL TROUT REDBAND TROUT RESEARCH PROJECT

Annual Report FY 1999

DOE/BP-00006313-1

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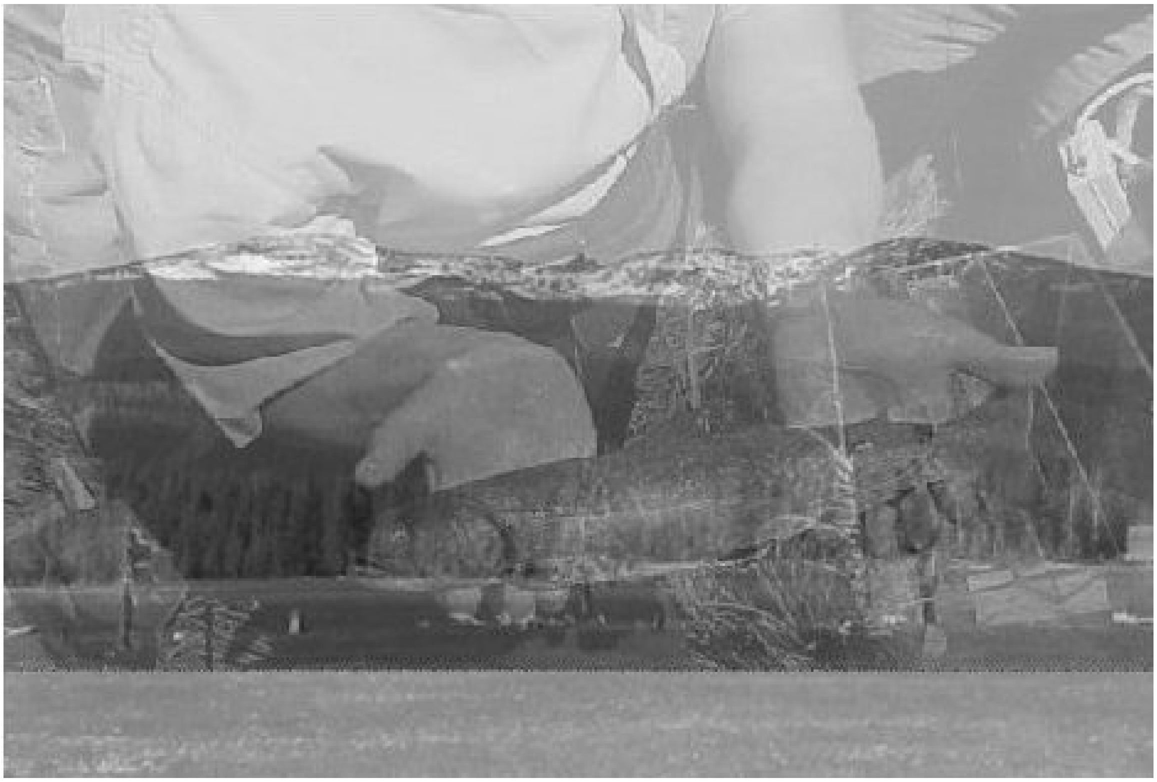

# Malheur River Basin

Cooperative Bull Trout/Redband Trout
Research Project

# Evaluation of the Life History of Native Salmonids in the Malheur River Basin (BPA project # 9701900/9701901)
## FY 1999 Annual Report


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# Table of Contents

## Bull Trout Reports



## Water/Habitat Quality Reports



## Redband Reports

# Use of radio telemetry to document movements of bull trout in the Malheur basin in Oregon

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## Introduction

The purpose of this study is to document the seasonal distribution of adult/sub-adult bull trout (*Salvelinus confluentus*) in the Malheur River basin. Due to the decline of bull trout in the Columbia Basin, the United States Fish and Wildlife Service listed bull trout as a threatened species in June 1998. Past land management activities; construction of dams; and fish eradication projects in the North Fork and Middle Fork Malheur River by poisoning have worked in concert to cumulatively impact native species in the Malheur Basin (Bowers et. al. 1993). Survival of the remaining bull trout populations is severely threatened (Buchanan 1997).

1999 Research Objects:

1) Document the migratory patterns of adult/sub-adult bull trout in the North Fork Malheur River
2) Determine the seasonal bull trout use of Beulah Reservoir and bull trout entrainment
3) Timing and location of bull trout spawning in the North Fork Malheur River basin

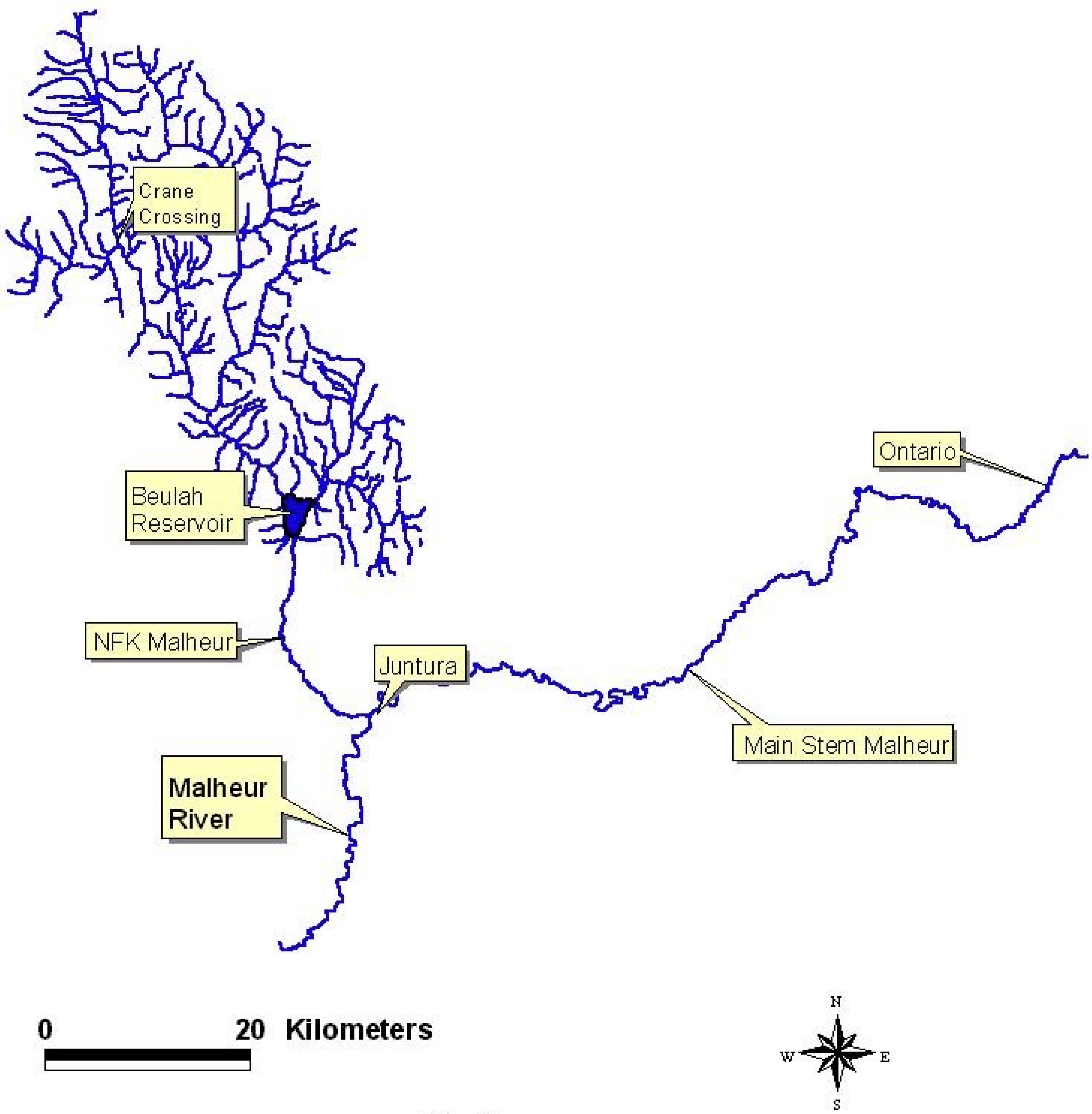
The study area includes the Malheur basin from the mouth of the Malheur River located near Ontario, Oregon to the headwaters of the North Fork Malheur River (Map 1). All fish collected and most of the telemetry effort was done on the North Fork Malheur River subbasin (Map 2). Fish collection was conducted on the North Fork Malheur River at the tailwaters of Beulah Reservoir (RK 29), Beulah Reservoir (RK 29 – RK 33), and in the North Fork Malheur River at Crane Crossing (RK 69) to the headwaters of the North Fork Malheur. Radio telemetry was done from the mouth of the Malheur River in Ontario, Oregon to the headwaters of the North Fork Malheur. This report will reflect all migration data collected from 3/1/99 to 12/31/99.

## Methods

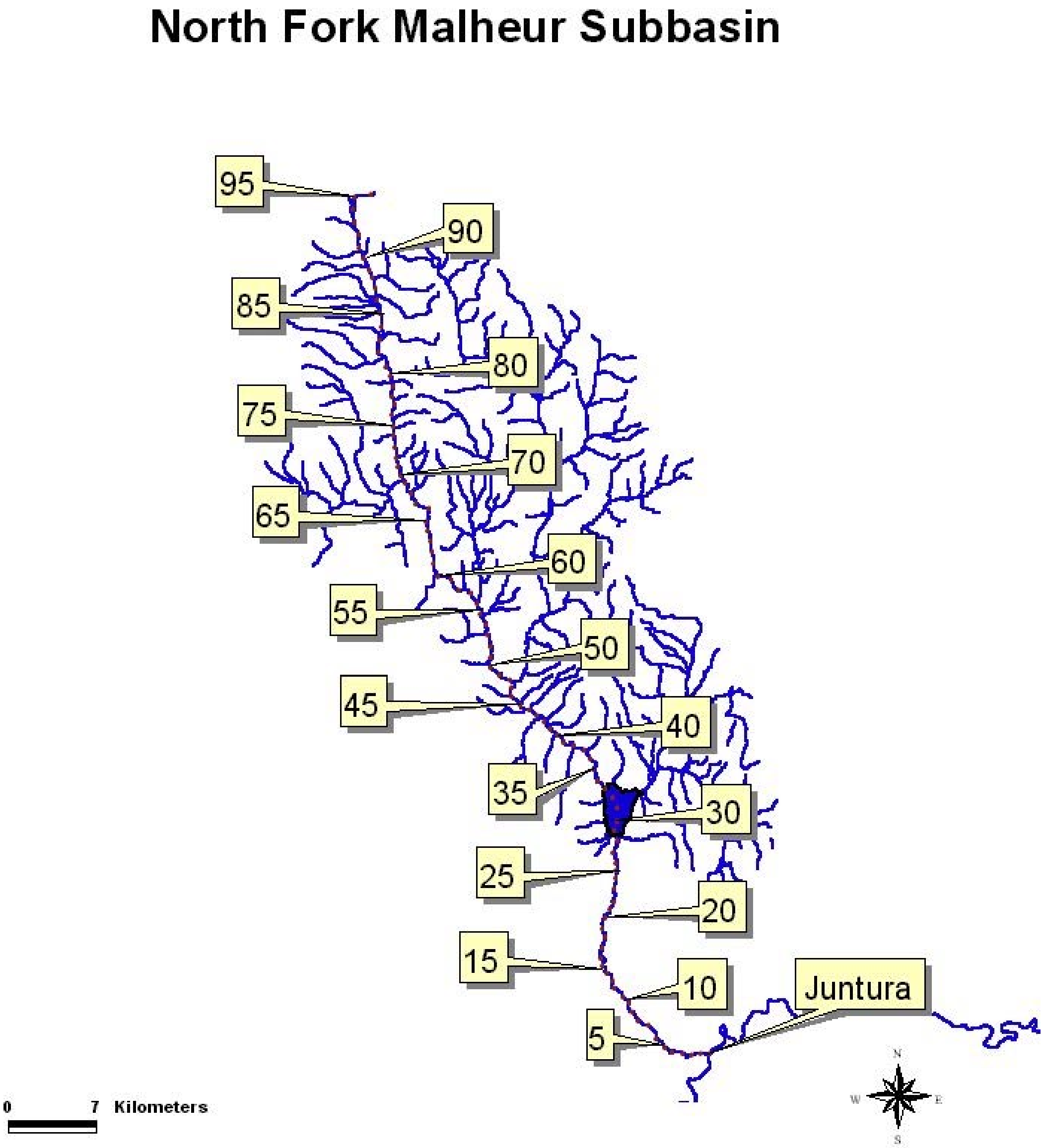
### *Fish Collection*

Bull trout were collected by angling in the tailrace of the Agency Valley Dam, in Beulah Reservoir, and in the North Fork Malheur River at the US Forest Service boundary (RK 56) and above to the headwaters. In addition to angling, two trap nets and four fyke nets were deployed in Beulah Reservoir shortly after ice-out and a screw trap placed in the North Fork Malheur River at Crane Crossing (RK 69). The reservoir traps were set on March 29$^{th}$ and removed on May 4, 1999 while the screw trap was set up on June 2, 1999 and removed on October 19, 1999. The reservoir traps were checked every other day and the screw trap at RK 69 was checked daily. Map 3 is the location of the reservoir trap nets in Beulah Reservoir.

# Malheur Basin

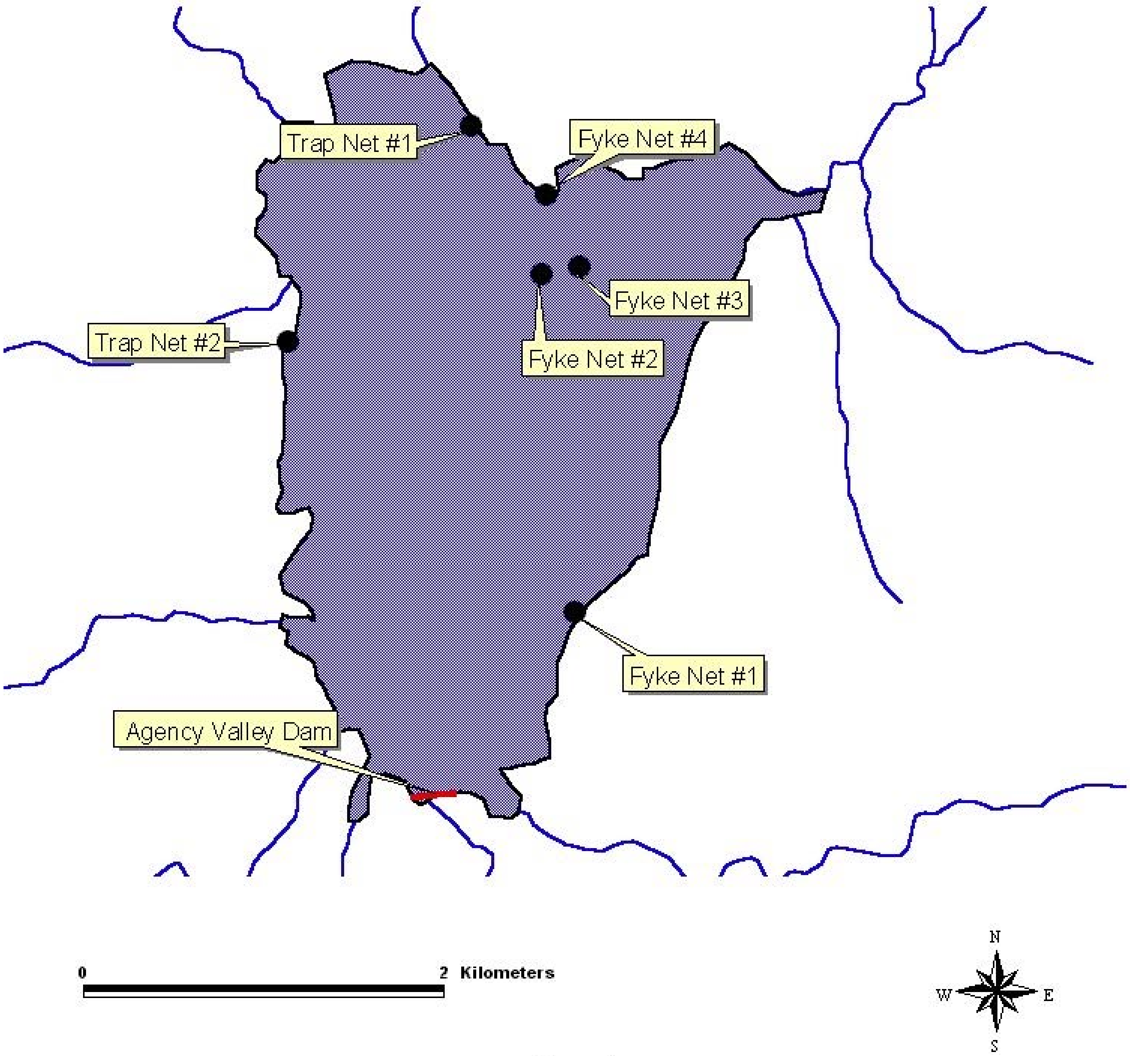



Map 1
1999 Project Area




Map 2
River Kilometers from Mouth of
North Fork Malheur to the Headwaters

# Location of Reservoir Traps




Map 3
Location of Fyke and Trap Nets in Beulah Reservoir

### *Radio and PIT Tag Implants*

Radio transmitters manufactured by Advanced Telemetry Systems Inc. (ATS) had external whip antennas that emitted a unique frequency in either the 150 or 151 MHz band. Radios came in three sizes and are guaranteed for up to 94+ days (8g radios), 175 days (11g radios) and 208 days (17g radios). Transmitter weight was not to exceed 3% of the bull trout body weight: 17g radio (for bull trout > 566g), 11 gm radio (for bull trout > 366g), 8g radio (for bull trout > 266g). Bull trout weighing less than 266g were not considered for implantation.

PIT tags were implanted into all bull trout that were 150 millimeters and larger. PIT tag injectors and 1 ¼ inch 12 gauge injector needles manufactured by BioMark Inc. were used to insert PIT tags into the muscle adjacent to the dorsal fin.

The Malheur Bull Trout Working Group set the maximum target of 25 radio tagged fish to be released above Agency Valley Dam and five released below the dam in the tailrace area. Radio tagged bull trout were to be released at the site of capture. Once the target of five radio tagged bull trout were released below Agency Valley Dam, additional bull trout caught in the tailrace would be tagged and hauled above the dam site to be released into the reservoir.

The screw trap was used to capture bull trout in the North Fork Malheur River at RK 69. Angling was done to collect additional bull trout for radio tagging. Captured fish were kept in live traps until a trained person was able to implant a transmitter and/or a PIT tag.

Captured bull trout were anesthetized with MS 222 (tricaine methanesulfonate) measured (fork length in mm) and weighed (g). Radio transmitters were inserted internally through a midline internal incision (Ross and Kleiner, 1982). The external whip antennas were threaded through the body cavity and exited behind the pelvic fin. Surgeries lasted 3-9 minutes (mean 6 min), during which time the gills were bathed with diluted MS 222 (60 mg / liter). Synthetic absorbable surgical sutures and super glue were used to seal the incision. After surgery, fish were held in fresh water until equilibrium was recovered, then released back into the reservoir. Fish tank aerators were used in all holding buckets to provide increase oxygen levels.

### *Radio Telemetry*

Radio telemetry commenced once the first successful surgery was completed on 3-12-99. The tracking of radio tagged bull trout was conducted on average four times a week to obtain an approximate location of each fish. An ATS (Advanced Telemetry Systems) receiver, Yagi antenna, and a 12 channel hand-held GPS unit were used to locate fish. Foot travel and a vehicle were the primary means to locate individual fish. Visual identification for the fish was preferred but rarely possible. The frequency of each fish, time located, and UTM location were recorded for all positive identifications. Aerial surveys were conducted from a fixed winged aircraft when tagged fish entered roadless or private areas. Boats were used to track fish in Beulah Reservoir. Fish were also tracked by capture, either by angling or by capture by the reservoir traps or screw trap. If applicable, comments were taken on fish locations that include stream temperatures, stream names, redds or pairing fish, and habitat/cover present.

## Results

## *Fish Collection*

The traps in Beulah Reservoir, the screw trap at Crane Crossing and anglers collected a total of 99 bull trout (table 1). Twenty-five of these fish were tagged with radio transmitters between the dates 3/11/99 to 7/21/99 (table 2). Eighteen fish were radio tagged and released in the reservoir and five fish radio tagged and released below Agency Dam. Two additional bull trout were caught and radio tagged in the North Fork Malheur (North Fork) in July at RK 69. The screw trap was ineffective in capture of bull trout large enough to receive a radio tag. The screw trap caught smaller bull trout (<300 mm fork length) and also collected recaptured PIT tagged bull trout. Tiley (2000) has written a detailed report of the screw trap operation in 1999 and the movement of PIT tagged sub-adult bull trout within the North Fork watershed.

Fish collected in the reservoir traps include; (1) bull trout, (2) redband/rainbow trout *Oncorhynchus mykiss spp*., (3) bridgelip sucker *Catostomus columbianus*, (4) course scale sucker *C. macrocheilus*, (5) redside shiner *Richardsonius balteatus*, and (6) mountain whitefish *Prosopium williamsoni*. Fish species collected by angling in the tailrace below Agency Valley dam include: (1) bull trout, (2) redband trout, (3) mountain whitefish, and (4) northern pike minnow *Ptychocheilus oregonensis.*

The last bull trout caught in the reservoir traps that was large enough for a radio tag implant (>280 grams) was caught on April 18, 1999. Four additional bull trout were caught using the reservoir trap nets from April 20$^{th}$ to May 4$^{th}$, but weight of each individual fish did not exceed 210 grams.

Table 1 – The table represents total fish caught in 1999 that does not include the recaptures. Numbers do reflect recaptures from the 1998 field season.

| Sampling Method | Number of Bull Trout Caught in 1999 (Does Not Include Recaptures) | Number Bull Trout That were Radio Tagged | Mean Length (mm) | Length Range (mm) | Mean Weight (gm) |
|---|---|---|---|---|---|
| **Angling below Agency Dam** | 17 | 13 | 379 | 255 – 510 | 550 |
| **Reservoir Traps** | 19 | 10 | 320 | 220 – 410 | 403 |
| **Angling above Crane Crossing** | 2 | 2 | 316 | 297 – 335 | 347 |
| **Screw Trap** | 61 | 0 | 179 | 141 – 253 | 59 |
| **Total** | **99** | **25** | | | |

A total of four bull trout radio tagged in 1998 were recaptured in 1999. Three of the four fish were re-tagged with new 1999 radio transmitters and released in the reservoir. Two of these fish were caught in the reservoir traps: one on 4/8/99 and the other on 4/10/99. Both of these fish had active 1998 radio implants at time of recapture. The other two were angled out of the tailrace below Agency Valley Dam: one on 4/3/99 and the other on 4/16/99. Both these fish had 8-gram 1998 radio implants and were not active at time of recapture. One fish did not revive after being angled from the spillway and was our only mortality in the collection process.

Table 2 – The table represents radio implant record for 1999. Twenty-five fish were radio tagged, 20 released above Agency Dam and 5 released below. "Tracked to Tributary" refers to documented spawning tributaries bull trout are known to use.
*- BUT-99-27 was physically moved downstream 14 km to Chuckar Park

| BUT ID Number | Radio Frequency | Date of Implant | Origin of Implant | Length (mm) | Weight in grams | Tracked to Tributary (KM above Beulah) | Maximum Distance |
|---|---|---|---|---|---|---|---|

| | | | | | | | Traveled (KM) |
|---|---|---|---|---|---|---|---|
| BUT-98-6 | 151.133 | 4/16/99 | Beulah Reservoir | 386 | 576 | None | 13 upstream |
| BUT-98-12 | 151.192 | 4/10/99 | Beulah Reservoir | 376 | 551 | North Fork Elk Creek | 53 upstream |
| BUT-98-18 | 150.922 | 4/8/99 | Beulah Reservoir | 400 | 748 | Sheep Creek | 58 upstream |
| BUT-99-20 | 150.433 | 4/4/99 | Beulah Reservoir | 410 | 827 | Swamp Creek | 62 upstream |
| BUT-99-21 | 150.522 | 4/18/99 | Beulah Reservoir | 448 | 947 | South Fork Elk Creek | 52 upstream |
| BUT-99-22 | 150.683 | 4/11/99 | Below Agency Dam | 424 | 850 | Below Agency Dam | 15 downstream |
| BUT-99-23 | 150.722 | 5/28/99 | Beulah Reservoir | 425 | 707 | Crane Creek | 39 upstream |
| BUT-99-24 | 150.803 | 4/14/99 | Beulah Reservoir | 387 | 631 | Below Agency Dam | 11 downstream |
| BUT-99-25 | 150.863 | 4/2/99 | Beulah Reservoir | 380 | 704 | None | 11 upstream |
| BUT-99-27 | 151.023 | 4/18/99 | Below Agency Dam | 410 | 622 | Below Agency Dam | 14 downstream* |
| BUT-99-28 | 151.152 | 4/22/99 | Below Agency Dam | 390 | 571 | Little Crane Creek | 53 upstream |
| BUT-99-29 | 151.173 | 5/28/99 | Beulah Reservoir | 385 | 538 | None | 45 upstream |
| BUT-99-30 | 151.182 | 6/8/99 | Beulah Reservoir | 510 | 1035 | None | 45 upstream |
| BUT-99-32 | 151.222 | 5/23/99 | Beulah Reservoir | 410 | 558 | Elk Creek | 50 upstream |
| BUT-99-33 | 151.293 | 5/23/99 | Beulah Reservoir | 400 | 562 | Elk Creek | 49 upstream |
| BUT-99-34 | 151.362 | 3/31/99 | Beulah Reservoir | 365 | 467 | Swamp Creek | 60 upstream |
| BUT-99-35 | 151.593 | 4/14/99 | Below Agency Dam | 387 | 582 | None | 34 upstream |
| BUT-99-36 | 151.683 | 4/18/99 | Beulah Reservoir | 317 | 281 | Below Agency Dam | 1 downstream |
| BUT-99-37 | 151.693 | 5/10/99 | Beulah Reservoir | 337 | 330 | None | 53 upstream |
| BUT-99-38 | 151.862 | 4/6/99 | Beulah Reservoir | 350 | 429 | None | 2 upstream |
| BUT-99-39 | 151.872 | 4/14/99 | Beulah Reservoir | 319 | 339 | Swamp Creek | 61 upstream |
| BUT-99-40 | 151.883 | 4/6/99 | Beulah Reservoir | 354 | 436 | Little Crane Creek | 45 upstream |
| BUT-99-41 | 151.892 | 3/11/99 | Below Agency Dam | 319 | 312 | Below Agency Dam | 3 downstream |
| BUT-99-42 | 151.753 | 7/21/99 | North Fork Malheur | 297 | 268 | Little Crane Creek | 53 upstream |
| BUT-99-43 | 151.853 | 7/21/99 | North Fork Malheur | 335 | 426 | None | 39 upstream |

### *Movements upstream of the damsite*

In 1999, six-hundred twenty-eight observations were documented with radio telemetry (Table 3). Most of the tracking effort was done on foot or by vehicle. The US Forest Service conducted aerial tracking by fixed wing aircraft for radio tagged bull trout six times in 1999. Appendix 1 displays 1999 telemetry results for all radio tagged fish from April through December.

Table 3 – Number of tracking observations observed during 1999.

| Capture Observations | Foot Observations | Vehicle Observations | Boat Observations | Plane Observations | **Total Observations** |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 7 | 238 | 209 | 80 | 90 | **628** |

Table 4 – Radio tagged bull trout migration up the North Fork Malheur River. The North Fork Malheur River is broken into four sections in the table below. Percent represent the number of radio tagged bull trout that successfully migrated from the previous section.

| | **1999** |
|---|---|
| Number of radio tagged bull trout that were released in Beulah Reservoir ***(RK 29 to RK 33)*** | 18 |
| Number of fish migrating into the Lower North Fork Malheur River ***(RK 33 to RK 69)*** | 18 (100%) |
| Number of fish that did not migrate out of Beulah Reservoir | 0 (0%) |
| Number of Radio Tag Bull Trout that migrated from the lower North Fork Malheur River above Crane Crossing. ***(RK 69+)*** | 14 (78%) |
| Number of radio tagged bull trout that did not migrate from the lower North Fork Malheur to the Upper North Fork Malheur River (Region above Crane Crossing) | 4 (22%) |
| Additional bull trout radio tagged above Crane Crossing | 2 |
| Total number of radio tagged bull trout observed above Crane Crossing | 16 |
| Number of radio tagged bull trout that migrated into Spawning Tributaries Above Crane Crossing | 12 (75%) |

Of the twenty bull trout radio tagged in 1999, twelve entered a known spawning tributary located above Crane Crossing (RK 69)(Table 4). Sixteen radio tagged bull trout were observed above Crane Crossing (RK 69).

Gonzalez et. al.(1999) found that two out of six radio tagged bull trout in 1998 returned to Beulah Reservoir by November 16, 1998. No telemetry effort was conducted until tracking effort resumed around the reservoir on 4/8/99. In April 1999, eight additional radio tagged fish from 1998 were found; seven bull trout in or below the reservoir and one 2 km upstream from the reservoir in the North Fork. Two of the eight radio tagged bull trout did not have active radios. These bull trout were collected in the tailrace below Agency Dam. A more intensive tracking effort in 1999 observed radio tagged bull trout in the reservoir as early as November 1st(table 5).

Tagged bull trout from 1998 were tracked in 1999 until their transmission could no longer be detected. Four radio tagged bull trout from 1998 gave us additional tracking data in 1999. Their migration behavior should not be affected by radio implant surgery that was done in the spring of 1998, giving the wounds one year to heal. Three of the four fish migrated out of Beulah Reservoir between mid April and early May.

During upstream migration, a radio tagged bull trout was observed 1 kilometer up the Little Malheur River in May 1999. In 1998, radio tagged bull trout were also found in the Little Malheur River in May and early June. All radio tagged bull trout that migrated up the Little Malheur River returned to the North Fork Malheur River and continued to migrate upstream.

Table 5 – List of bull trout that returned from the headwaters of the North Fork Malheur River back to Beulah Reservoir in 1998 and 1999. In 1998, there was minimal radio tracking data collected at Beulah Reservoir in the fall. In 1999, the tracking effort was increased to determine the time of year bull trout return to the reservoir. Additional fish may be present in the reservoir as smaller radio tags tend expire due to shorter battery life.

| **BUT ID # Frequency *1998 Implants*** | **Date Fish Returned To Reservoir** | **Radio Active At Date Fish Returned** | | **BUT ID # Frequency *1999 Implants*** | **Date Fish Returned To Reservoir** | **Radio Active At Date Fish Returned** |
|---|---|---|---|---|---|---|
| BUT-98-12 151.582 | 11/16/98 | Yes | | BUT-99-35 151.593 | 12/13/99 | Yes |
| BUT-98-14 151.653 | 11/16/98 | Yes | | BUT-99-20 150.433 | 11/1/99 | Yes |
| BUT-98-11 151.542 | 4/3/99 | No | | BUT-99-21 150.522 | 11/1/99 | Yes |
| BUT-98-1 151.392 | 4/8/99 | Yes | | BUT-98-12 151.192 | 11/8/99 | Yes |
| BUT-98-18 151.803 | 4/8/99 | Yes | | BUT-99-28 151.152 | 11/8/99 | Yes |
| BUT-98-13 151.603 | 4/15/99 | Yes | | BUT-98-18 150.922 | 11/30/99 | Yes |
| BUT-98-6 151.463 | 4/16/99 | No | | | | |

The two bull trout that were tagged near Crane Crossing (RK 69) did not migrate downstream to the reservoir in the fall. Bull trout 99-42 was caught on 7/21/99 at Crane Crossing. 99-42 migrated to upper Little Crane Creek and returned to Crane Crossing on 9/27/99. 99-42 remained in the Crane Crossing area until snow made accessibility difficult by December 1999. Bull trout 99-43 was implanted with a radio tag on 7/21/99 near Crane Crossing (RK 69). 99-43 remained near the mouth of Crane Creek (RK 70) for 37 days. This fish migrated downstream and was found 3 km above the reservoir on 11/8/99. Instead of drifting back into the reservoir, 99-43 migrated upstream onto the Castle Rock Ranch. Crews did not have permission to track on private land. 99-43 continued to migrate upstream and eventually migrated out of range by mid December 1999.

### *Movements downstream of dam site*

In general, radio tagged bull trout below Agency Dam held near the damsite. Several bull trout migrated back and forth from downstream pools to the tailrace, but most did not migrate over 1.5 km downstream from the damsite. Only two radio tagged bull trout were observed over 2 km downstream from the damsite. The radios from these bull trout were recovered after water release from the reservoir was shut off in October 1999.

Bull trout 99-24 was radio tagged on 4/11/99. 99-24 remained within 2 km of the dam site for 102 days and then was not detected. 99-24 was not found for 12 days until it was tracked by a ranch house 10 kilometers below the damsite. 99-24 did not move for 140 days until the radio was recovered from a diversion ditch in mid November 1999. No bull trout remains were found.

Bull trout 99-22 was also implanted with a radio tag on 4/11/99. 99-22 remained within 2 km of the dam site for 30 days. 99-22 was not found for 24 days until it was tracked just below Chukar Park on private land about 15 km below the dam site. 99-22 remained in the same location for 150 days until the radio was recovered on November 8$^{th}$. No bull trout remains were found.

### *Entrainment*

Agency Valley Dam can release water by releasing water over the spillway or releasing water through tubes at the bottom of the reservoir. The operational plan for Agency Dam is to pass inflow over the spillway early in the year and then release water throughout the summer through the tubes starting in June (depending on runoff conditions).

For the two-year telemetry study, a total of four radio tagged bull trout out of 39 were entrained over Agency Dam. Of the bull trout implanted with radio tags in 1998, two were collected in tailrace below the dam in the spring of 1999. Both of these radio transmitters were not active at time of capture. The last radio-telemetry observation for both bull trout was in early September 1998 and both were located above Crane Crossing (RK 69). Both bull trout were tagged with 8-gram radio transmitters and it is likely the batteries have expired in September 1998. Since water release out of the reservoir was shut off 15 October 1998, fall entrainment could only occur before this date. It is undetermined if these bull trout were entrained in the fall or spring. Of the bull trout implanted with radio tags in 1999, two fish were entrained over Agency Valley Dam in May 1999. Radio telemetry was used to pinpoint their locations in the tailrace.

### *Migration of Re-tagged Bull Trout from 1998*

Three bull trout radio tagged in 1998 were caught and retagged in 1999. Bull trout 98-12 migrated to Horseshoe Creek in 1998 and to Elk Creek in 1999. Bull trout 98-18 was found in Sheep Creek in both 1998 and 1999. 98-6 migrated from the reservoir up to RK 45 by June 15, 1999 and has not moved. As of 12/31/99, the radio is still active and telemetry effort will continue to document any movements.

## Discussion

### *Fish Collection*

The minimum length of bull trout caught in the reservoir traps in 1998 and 1999 is 232 mm and 220 mm respectively. The smallest bull trout that was collected from the reservoir and radio tagged was 317 mm in length. All radio tagged bull trout in 1999 migrated upstream out of the reservoir, including the smaller radio tagged bull trout (~320 mm in length). Tiley (2000) found bull trout ranging from 120-270 mm migrating downstream at the screw trap site (RK 69) in June 1999. It is undetermined when these subadults from Crane Crossing (RK 69) migrate into the reservoir and when the smaller bull trout (220 mm to 316 mm) in the reservoir migrate out. A subadult bull trout study is needed to better understand the time and age subadult bull trout leave the headwater streams and migrate to the reservoir, the duration of time these bull trout reside in the reservoir, and when they migrate out of the reservoir to return to the spawning streams of the North Fork.

### *Movements upstream of the dam site*

Figure 1illustrates the movement of radio tagged bull trout in the North Fork Malheur basin for 1999. Using the telemetry data collected during 1999, we found that bull trout migration out of the reservoir begins in mid April and continued until late May. Radio tagged bull trout were observed above Crane Crossing (RK 69) in early June, with the majority of the fish migrating above Crane Crossing by the first of August. Fish entered the spawning tributaries as early as the first part of July with peak migration in mid August. Downstream migration out of the spawning tributaries peaked in late September, soon after the peak of the bull trout spawning (Perkins, 2000). Radio tagged bull trout returned to the reservoir in late October to mid December, with peak returns to the reservoir occurring in November.

Results from our second year of data collection are similar to that found by Gonzalez et. al. (1999) in 1998. Gonzalez found radio tagged bull trout distributed from Beulah Reservoir up to Elk Creek in mid June, a distance of approximately 50 km. In 1999, tracking effort for the first week in June had radio tagged bull trout distributed from Beulah Reservoir up to the mouth of Dugout Creek, a distance of approximately 42 km. Though Gonzalez reported all fish migrated into spawning tributaries by mid August 1998, we found that three radio tagged bull trout in 1999 did not migrate into a spawning tributary. One bull trout migrated only to river kilometer 64 by 10 September 1999. Two other radio tagged bull trout were observed near river kilometer 77 in early September 1999. It is undetermined if these bull trout utilized the mainstem to spawn. Twelve radio tagged bull trout were observed in four headwater drainages of the North Fork Malheur River above Crane Crossing (Table 6). Radio tagged bull trout did migrated into the Little Malheur River early in the spring. All bull trout that were observed in the Little Malheur River migrated back to the North Fork within two weeks and continued to migrate upstream.

Table 6 – Twelve bull trout found in spawning tributaries above Crane Crossing (RK 69).

| Drainage | Number of Radio Tagged Bull Trout |
|---|---|
| Crane Creek Drainage | 4 |
| Elk Creek Drainage | 4 |
| Swamp Creek Drainage | 3 |
| Sheep Creek Drainage | 1 |

In some cases, we had to assume radio tagged bull trout have died or shed their tags if the bull trout lacked movement for extended periods of time (>1 month). Telemetry effort on private land was limited to aerial tracking. The North Fork is primarily private land from RK 34 to 55. We were not permitted on private land to groundtruth aerial flights. Recovering radio tags or groundtruthing observations from the deep water in Beulah Reservoir (RK 29 to 34) was not possible without diving gear. Since we could not groundtruth these areas, we had to rely on the GPS coordinates taken from the aerial and boat tracking effort. We found that three bull trout from river kilometer 29 to 55 lacked up or downstream movement and were assumed dead or have shed their tag (Figure 2). These bull trout have died or expelled their tags during pre-spawn migration.

Reviewing the comment section on the telemetry data sheets, bull trout would hold in areas that had good cover, such as undercut banks and/or under debris jams. Though some bull trout held in areas below the confluence of major spawning tributaries, others migrated directly into the spawning tributaries. The bull trout that did hold in areas below the confluence of major spawning tributaries were associated with undercut banks and complex wood structures. Radio tagged bull trout were usually tracked on a weekly basis. A more intensive telemetry effort needs to be done to determine if bull trout stage for a short period of time (<1 week) prior to migration into spawning tributaries.

Bull trout caught in the tailrace below Agency Dam that were radio tagged and released in the reservoir migrated upstream to known spawning tributaries of the North Fork Malheur basin. Flatter (1997) observed similar results in the Boise River basin. Bull trout caught in Lucky Peak Lake were radio tagged and released upstream into Arrowrock Reservoir, these bull trout then demonstrated adfluvial life history characteristics.

Before the construction of Agency Dam, bull trout in the North Fork Malheur River demonstrated either resident or fluvial life history behaviors. The two bull trout caught and radio tagged at Crane Crossing (RK 69) overwintered in the North Fork. Both of these fish were smaller than 335 millimeters. A scale analysis needs to be done to determine if growth rates in Beulah Reservoir differ to those found in the North Fork.

Telemetry results suggest winter distrubution of adult bull trout (>297 mm length) are present in the mainstem North Fork Malheur River from Beulah Reservoir upstream to Crane Crossing (RK 69). Research is needed to determine if resident forms are present in the headwaters streams. For the two-year study, we found that the summer distribution of adult bull trout (>297 mm length) is limited to the North Fork Malheur River above RK 60 to the headwater streams located above Crane Crossing (RK 69). A sub-adult/juvenile study is needed to determine life history behavior and the seasonal distribution of bull trout that are less than 297 mm in length.

Radio telemetry will continue in the North Fork Malheur River in 2000 on radio tagged bull trout that still have active radios. This will be done to collect additional migratory data on radio tagged bull trout. Results from telemetry work conducted in 2000 will be reported in the 2001 report.

## *Movements downstream of dam site*

Radio tagged bull trout released below Agency Dam tend to stay within 2 km of the dam site (Figure 3). Bull trout that were found over 2 km downstream from the damsite either perished or shed their tag. The number of days bull trout remained in the tailrace ranged from 14 to 100 days. One out of the five radio tagged bull trout lived through the summer. Three radio tags were recovered from bull trout that died or expelled their radio tags. One bull trout was tracked only one week after surgery and was not detected afterwards.

A genetic analysis of bull trout collected below Agency Valley Dam needs to be conducted to determine their genetic origin. Agency Valley Dam is a barrier for upstream migratory bull trout. It is undetermined if bull trout that live through the summer below Agency Valley Dam are able to migrate downstream in the fall to the Snake River. It is also undetermined if bull trout from the Snake River can migrate upstream to Agency Dam in the spring.

## *Entrainment*

Entrained bull trout in the spring of 1999 was observed. Bull trout are at risk of being entrained when water is released over the top of Agency Valley Dam, particularly in the winter and spring. In 2000, the United States Bureau of Reclamation (USBR) will try to release water through the tubes at the bottom of the reservoir. The maximum capacity for water release out of the tubes is 950 cfs. If inflow exceeds this amount, the BOR will have to release water over the top of Agency Dam. The effect of water release through the tubes has on the entrainment of bull trout has not been determined. The USBR and the Tribe will continue to monitor entrainment over the Agency Valley Dam in 2000. The USBR and the Tribe are conducting a truck and haul operation for bull trout collected in the tailrace and moving them above the damsite.

Water release out of Beulah Reservoir is completely shut off in mid October. Fall entrainment of adult bull trout (>315 mm in length) over Agency Dam needs to occur prior to the shut off date. The peak migration of adult bull trout into Beulah Reservoir occurs in November with early bull trout returning in late October. The Tribe and the USBR will sample in the tailrace in the fall of 2000.

The USBR in response to the biological opinion has been collecting water quality data from Beulah beginning in 1999 and into 2000. This information will be used for determination of a bull trout conservation pool since there is currently no dedicated conservation pool for fish.

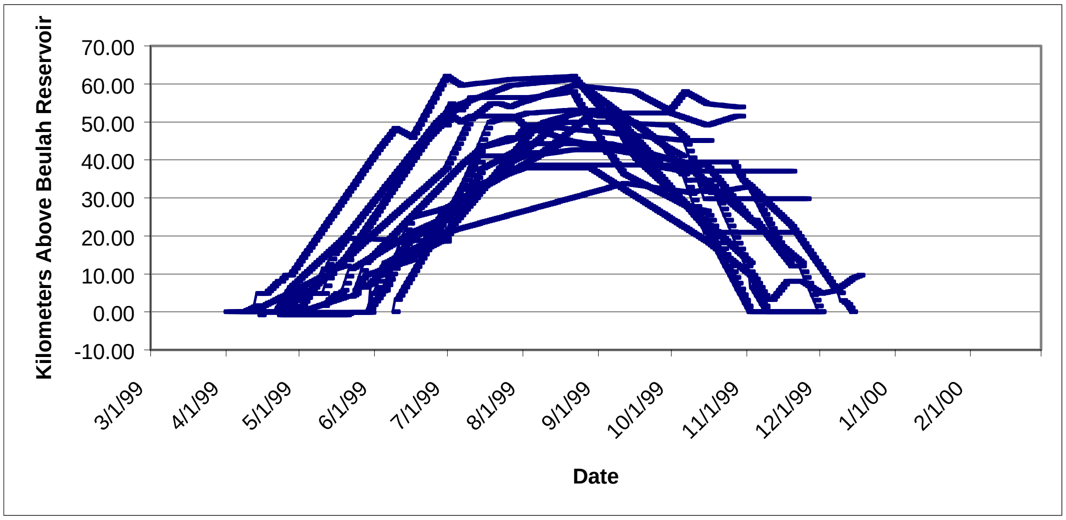



Figure 1 – 1999 bull trout migration. Graph includes all fish tracking observations during the field season of 1999.

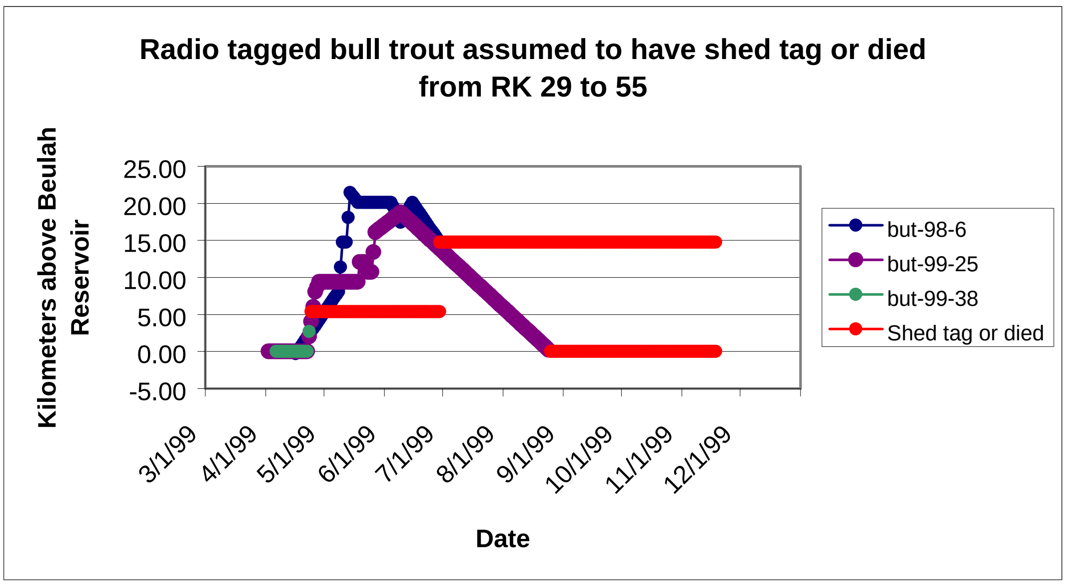



Figure 2 – Radio tagged bull trout that are assumed dead or have shed their tag during upstream migration. Bull trout were tracked by boat or during aerial flights, but were not able to be groundtruthed due to private land or located to deep in Beulah Reservoir. These bull trout lacked upstream or downstream movement. The red lines in the graph above represent the time frame the bull trout remained in the same location.

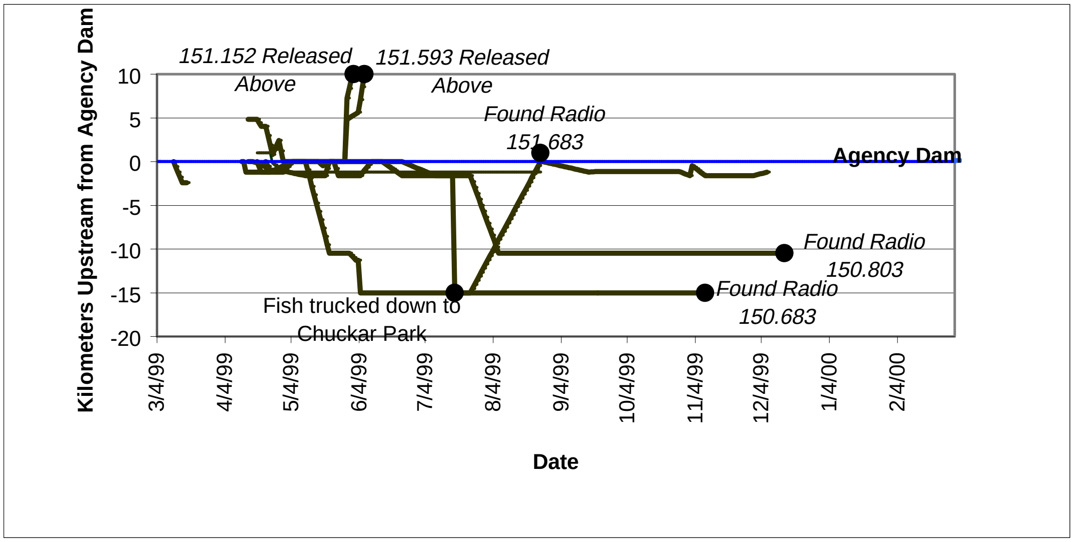



Figure 1.a.2 – Migration of 1999 radio tagged bull trout that were tracked below Agency Dam.

*Migration of Re-tagged Bull Trout from 1998*

Of the three fish that were retagged in 1999, one fish either perished or expelled radio near RK 45. One bull trout returned to the same spawning tributary as the year before but the other did not (appendix 2). Though the sample size of three fish is small, tracking data does not suggest bull trout spawn in natal tributaries in the upper North Fork Malheur basin. The ODFW has documented bull trout spawning in Horseshoe Creek, Elk Creek, Swamp Creek, Sheep Creek, and headwaters of the North Fork Malheur River. These streams flow together within 9.5 km section of river. The confluence of Crane Creek is approximately 8 km downstream from these tributaries. The separation between Crane Creek from the other tributaries may be significant enough that bull trout stray rate may be reduced but has not been researched.

# Acknowledgements

A special thanks is extended to: Wayne Bowers (ODFW), Ray Perkins (ODFW), Rick Rieber (BOR), and Allen Mauer (USFS) who donated equipment, knowledge, and time to the project; Sarah Bush (USFS) for her time tracking tag fish and GIS mapping skills; Mark Tiley (BPT), Newton SkunkCap (BPT), Garrett Sam (BPT), and Jason Fenton (BPT) who spent hours of data collection in the field; and Cynthia Tate (BLM) for her participation in the work group and snorkel skills. Bonneville Power Administration provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this study. Bureau of Reclamation provided funds needed for extra personnel.

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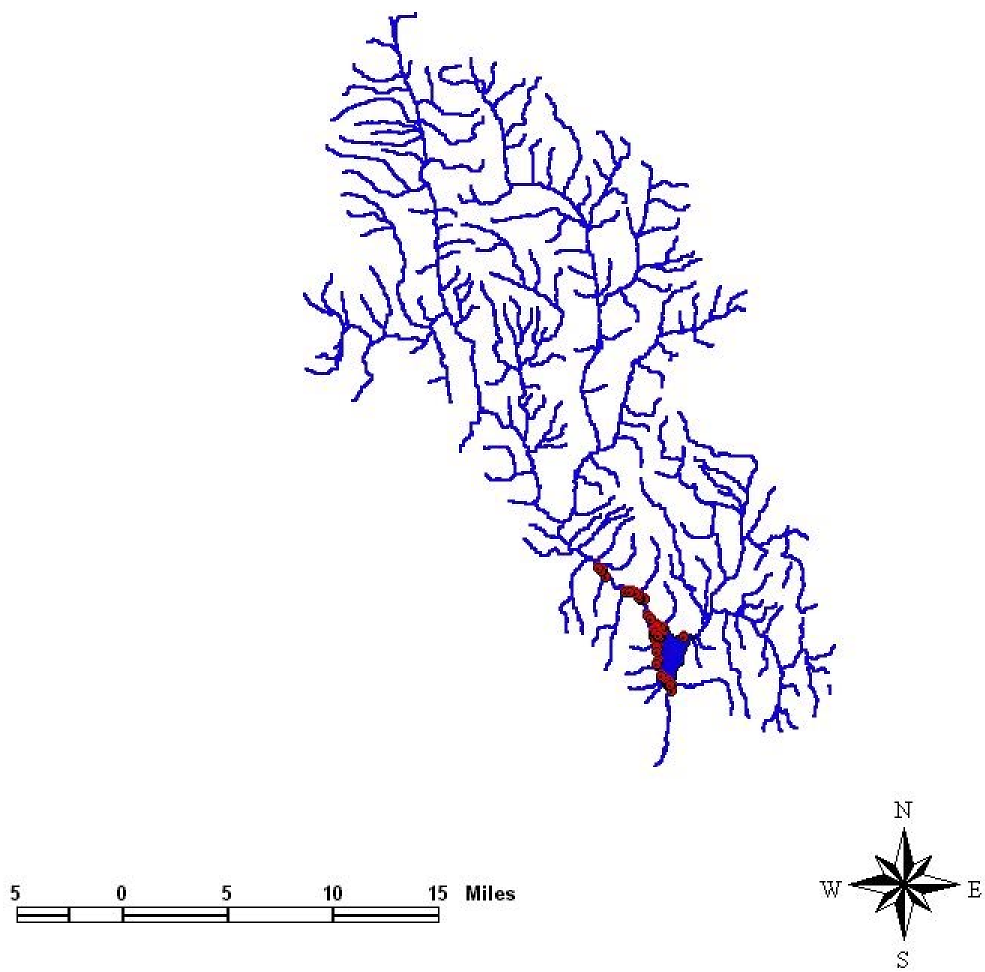
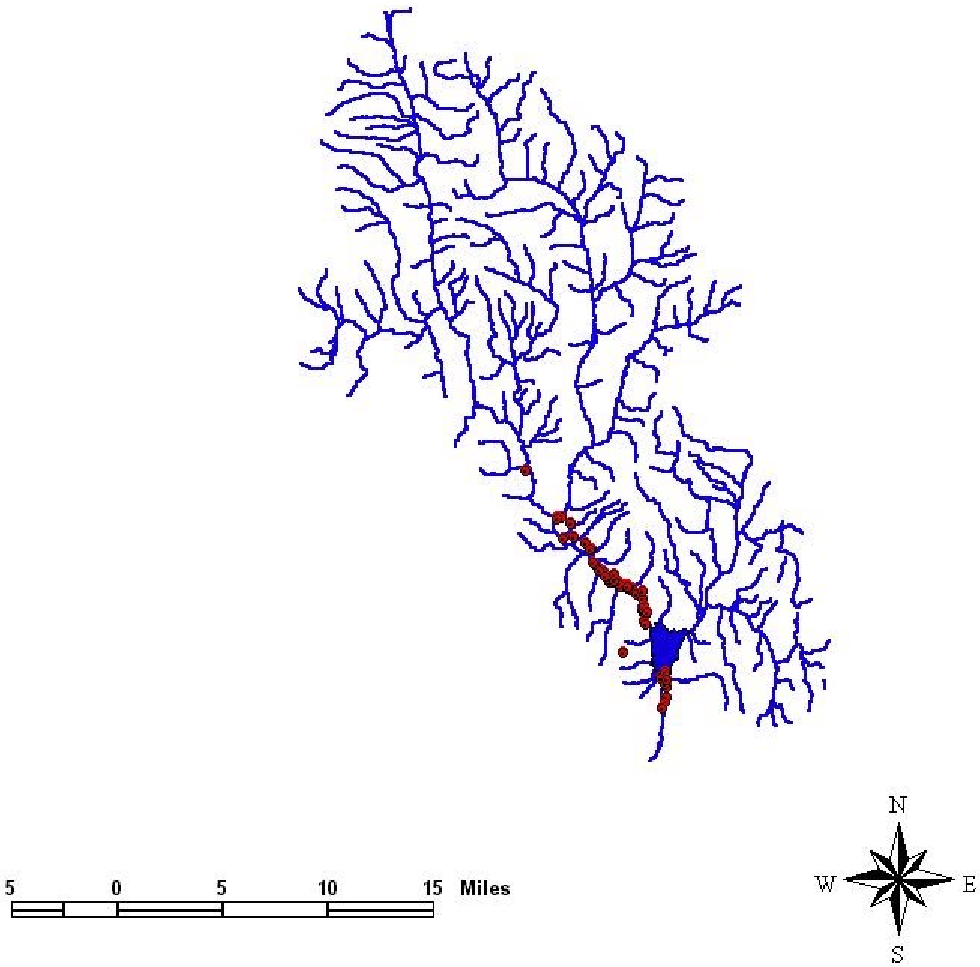
# Appendix 1
# 1999 Radio tagged bull trout migration.

This appendix consists of GIS maps with the locations of radio tagged bull trout in the North Fork Malheur basin. The first set of maps displays the location of all radio tagged bull trout observations for the month. The last map displays the highest observation for each radio tagged bull trout.

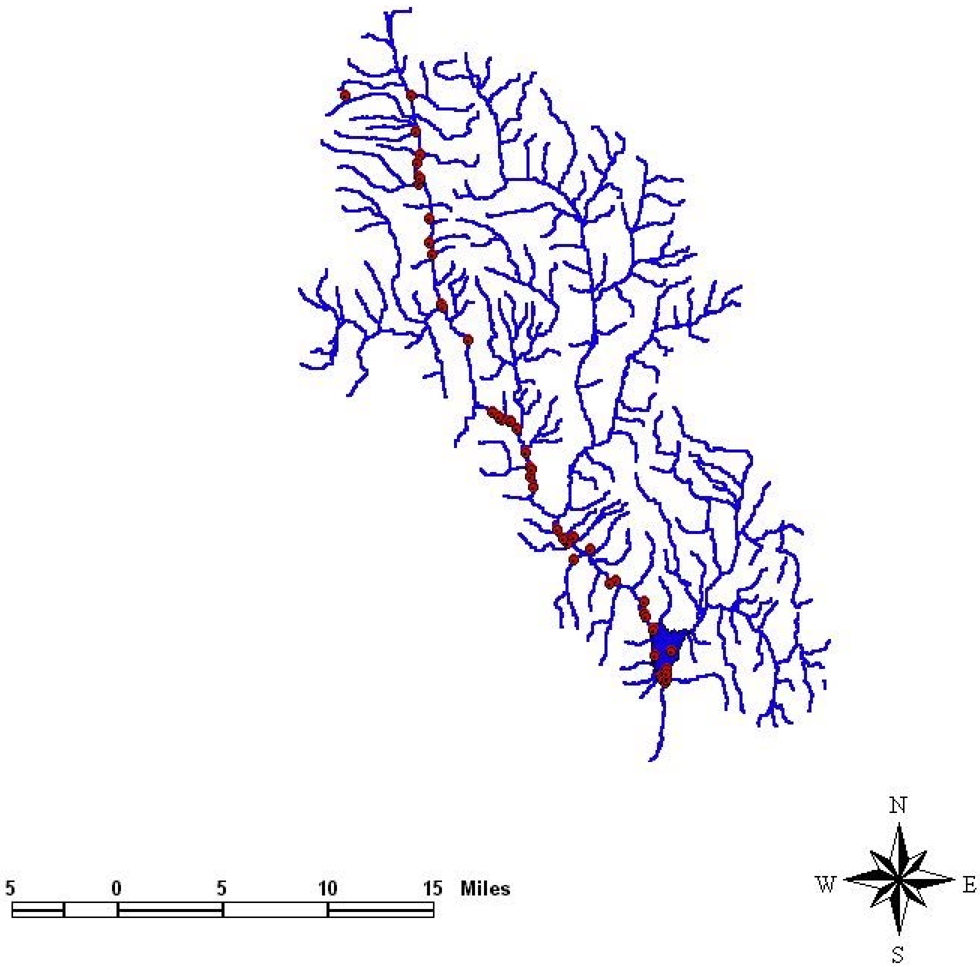
# April 1999



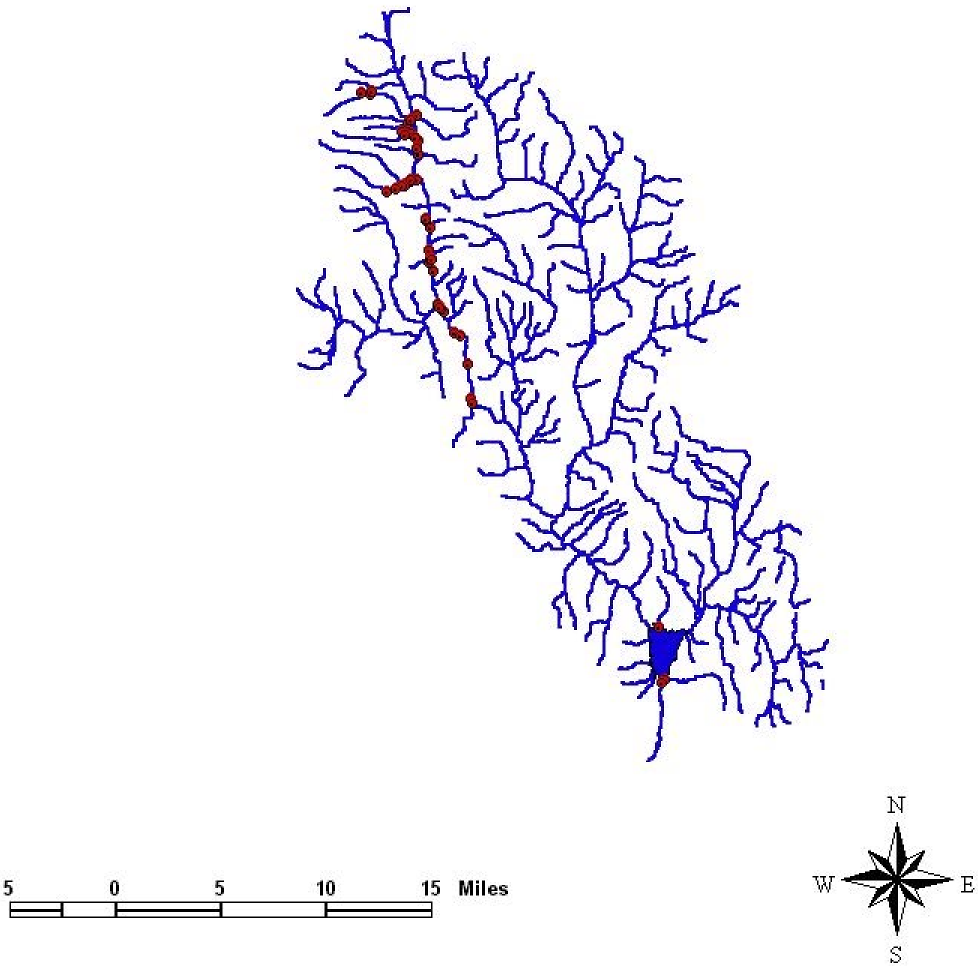
## May 1999



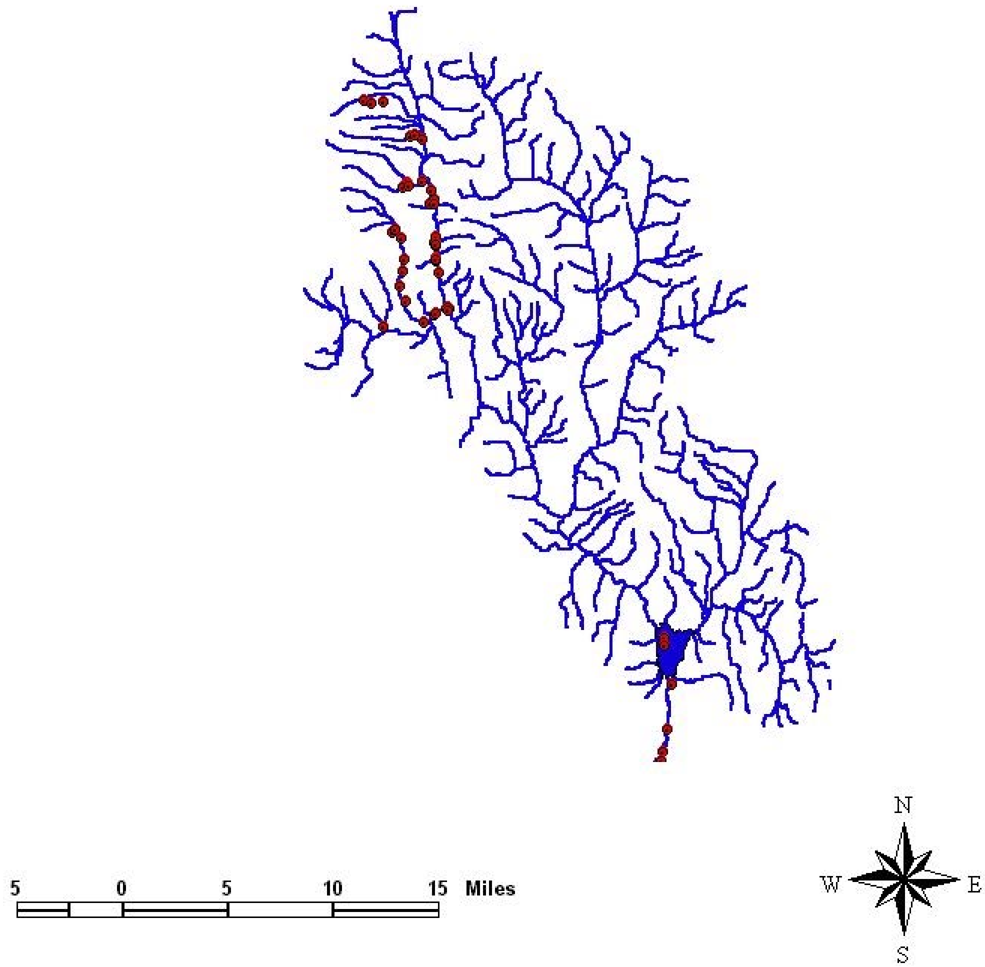
# June 1999



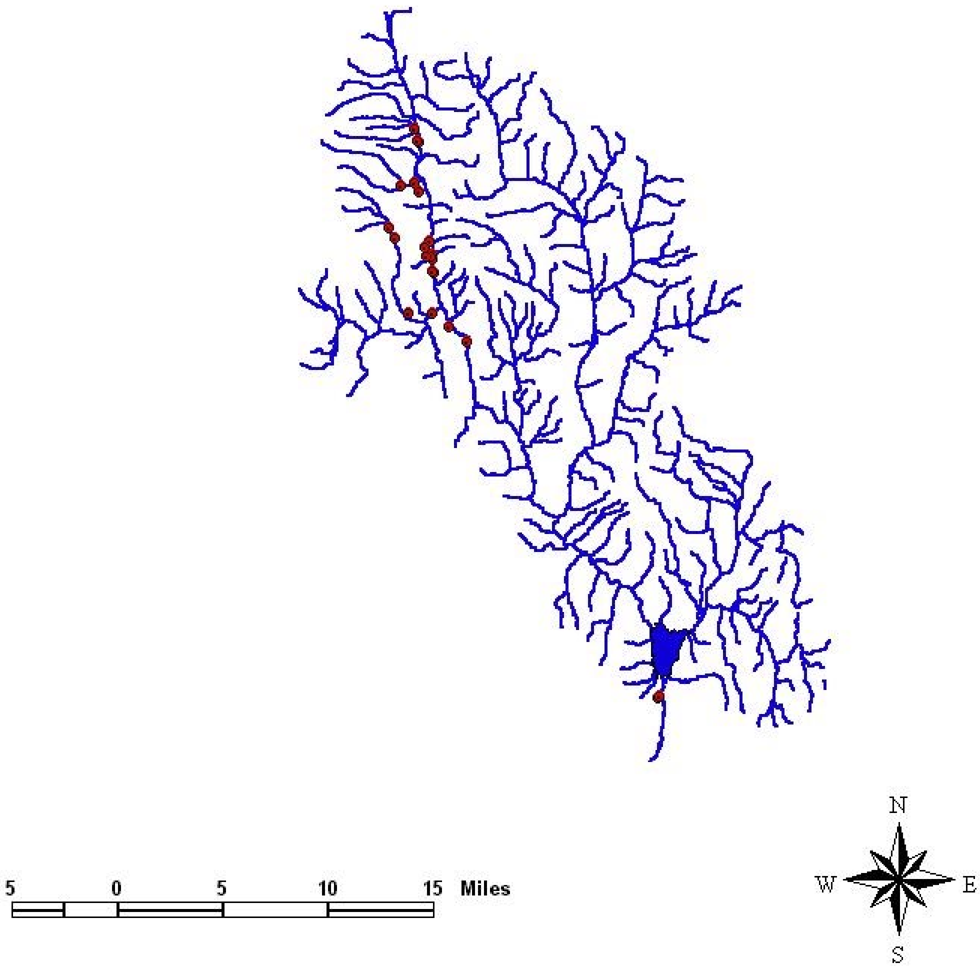
# July 1999



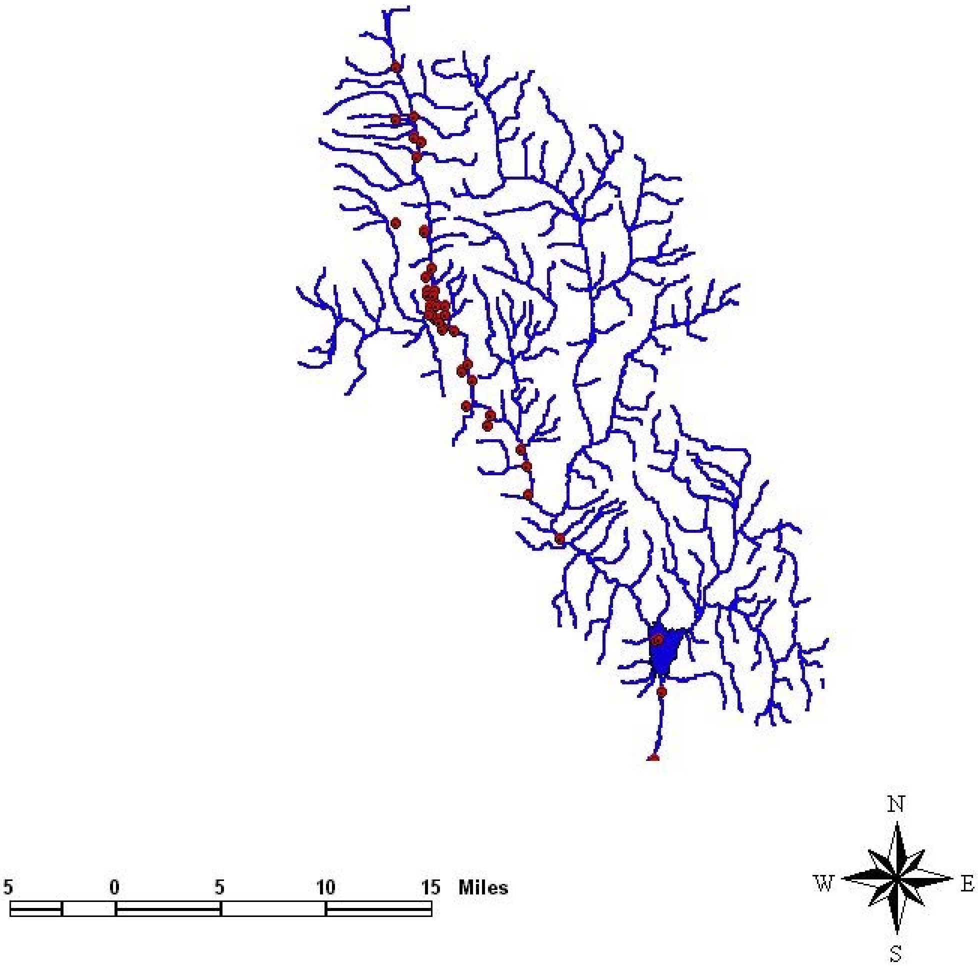
## August 1999



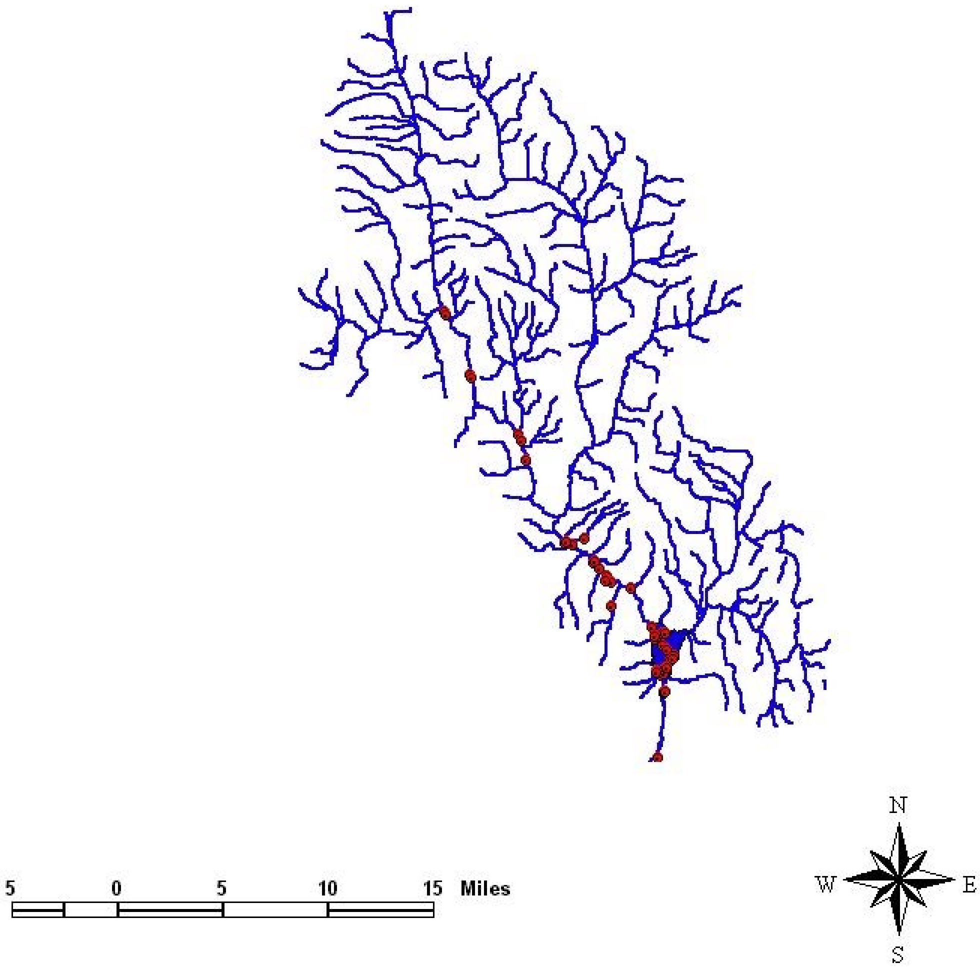
## September 1999



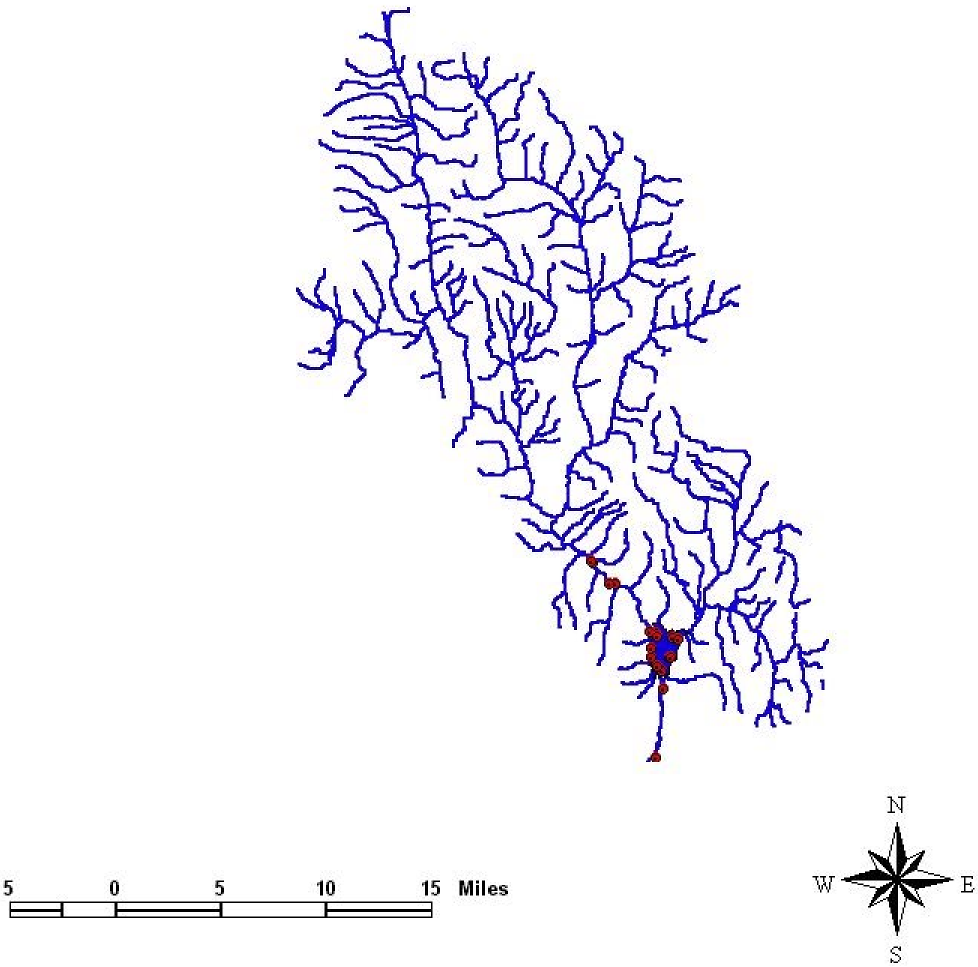
# October 1999

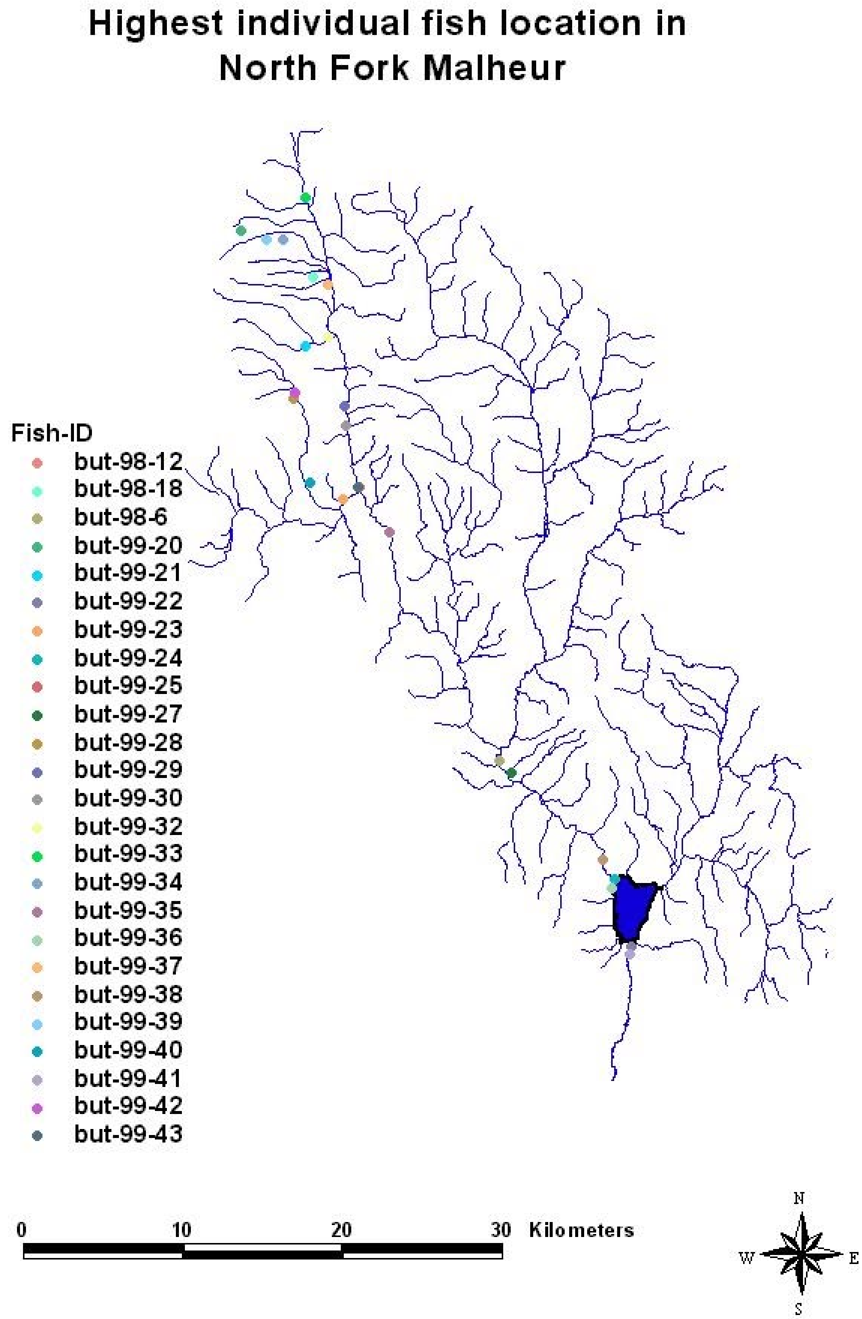


# November 1999



# December 1999




Highest individual fish location in
North Fork Malheur
Fish-ID
but-98-12
but-98-18
but-98-6
but-99-20
but-99-21
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but-99-23
but-99-24
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but-99-40
but-99-41
but-99-42
but-99-43
0
10
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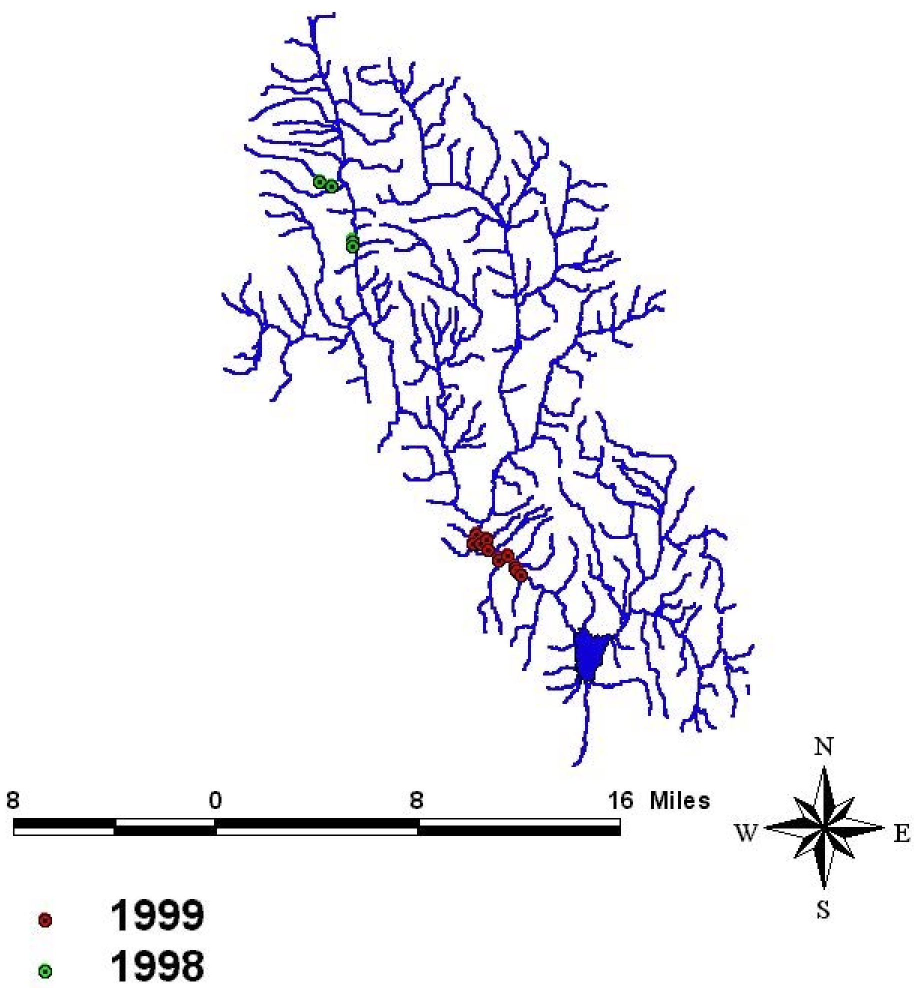
30
Kilometers
N
W
E
S

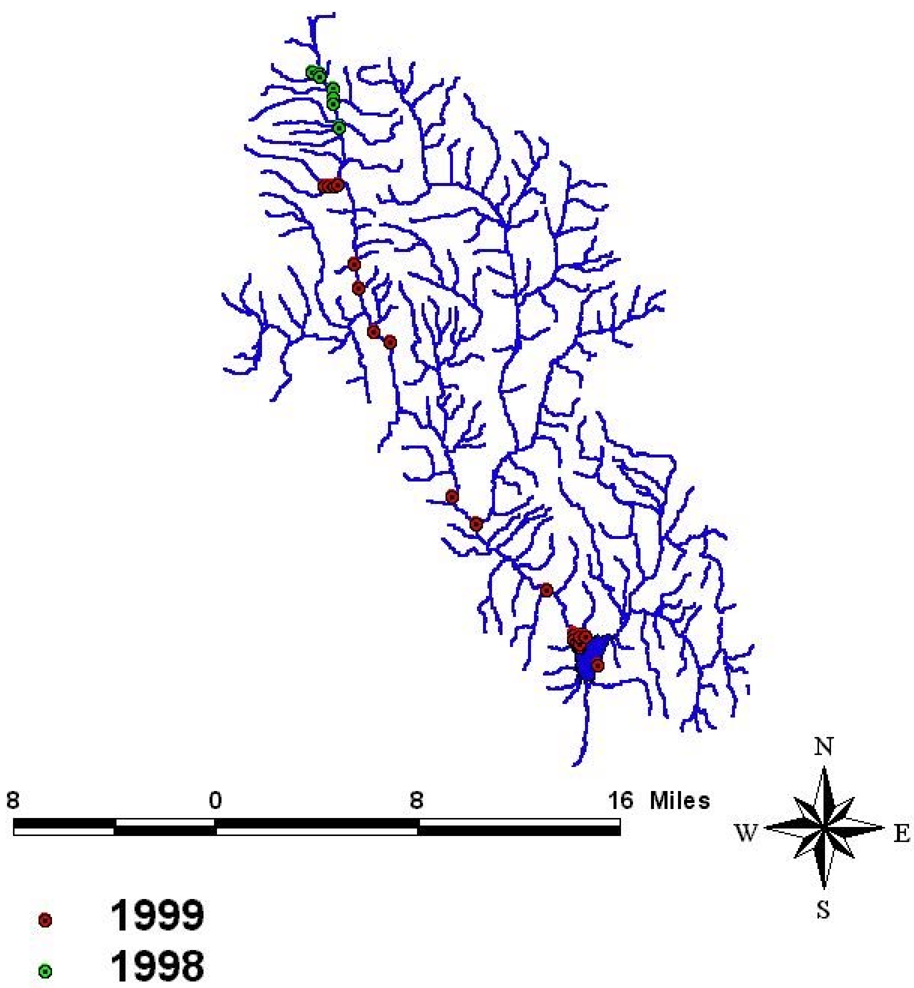
# Appendix 2
# Migration of re-tagged bull trout.

This appendix consists of GIS maps with the locations of three bull trout that were tagged in 1998 and re-tagged in 1999. Each map corresponds to one radio tagged bull trout, but for two years of migration data obtained by radio telemetry. Years are color coded according to the given legend.

# But-98-6



# But-98-12



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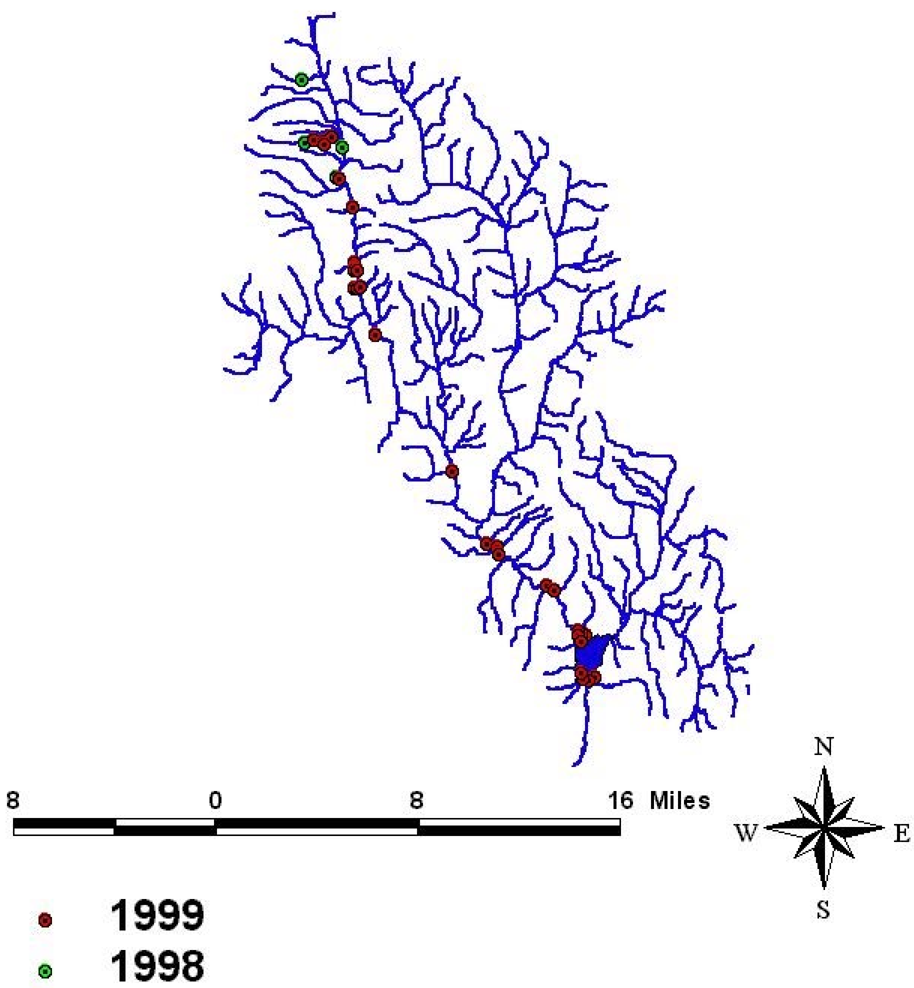

# *Analysis of bull trout* Salvelinus confluentus *migration data collected by rotary screw trap in the North Fork Malheur River, Oregon.*

Author: Mark Tiley, Burns Paiute Fish and Wildlife Department, Burns, Oregon

## Introduction

The North Fork Malheur River bull trout population has declined in recent history as a result of (i) past land and fisheries management practices, (ii) the presence of the Agency Valley Dam forming Beulah Reservoir in 1935 and (iii) the loss of anadromous prey fishes such as the chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) by damming throughout the Snake River system (Gonzalez, 1999). It is currently the intent of Federal, State and Tribal natural resource Agencies to reverse the Malheur River bull trout decline and restore populations to harvestable numbers and ensure long-term survival. Agencies are currently working collaboratively to develop an understanding of the bull trout life history in the North Fork Malheur River, a necessary task for the restoration of these bull trout populations.

The North Fork Malheur River bull trout (*Salvelinus confluentus*) population is currently the largest in the upper Malheur River Drainage (ODFW annual report archives) and is probably the most secure. Based on redd count data from 1998 to present, the bull trout population of the Middle Fork Malheur River is comparatively smaller (Perkins, 1999), and is sympatric with an introduced population of brook trout (*Salvelinus fontinalis*). Brook trout hybridize with bull trout in the Middle Fork Malheur (Markle, 1992) and likely compete with bull trout for resources (Dambacher et al. 1992). The larger North Fork population was selected for initial study because the absence of brook trout in the North Fork basin would not interfere with bull trout migration.

Research on the life history and distribution of the North Fork Malheur River bull trout was started in 1992 with redd counts that closely coincided with the ban of bull trout harvest in the Malheur system in early spring, 1991 (Bowers et al. 1993). The migratory behavior of fluvial/adfluvial adult bull trout has identified spawning and overwintering locations that are discussed in Chapter 1 of this report. However, there is no data on subadult fluvial or adfluvial bull trout migratory behavior aside from the limited rotary screw trap data and none on subadult habitat use. Such data is necessary for a complete understanding of Malheur watershed bull trout life history and effective population management. Although limited in scope, this chapter discusses results on subadult migration behavior from rotary screw trap data in the Malheur North Fork River.

## Methods

The Malheur River North Fork bull trout downstream migration was monitored with a 1.52 meter (m) (5 foot) rotary screw trap (the trap) from June 02, 1999, the date the trap was in place to October 19, 1999, when the trap was removed. The study site was located downstream of Crane Creek at UTM (Universal Transverse Mercator) coordinates 0390471E; 4896260N. This site was selected as it was downstream of all known bull trout spawning tributaries, road accessibility was good, and the channel narrowed into a bottle neck which scoured a narrow, deep pool which would increase the trapping efficiency (see Figure 1). Screw trap operation was continuous except for the period from September 03, 1999 to September 08, 1999 when all available staff was needed to conduct bull trout redd surveys. By mid October, freezing temperatures in the North Fork would result in a noticeable drop in discharge over night, causing the screw trap to catch on the stream bottom and seize-up. Thus, the trap was removed on October 19, 1999 to avoid damaging the trap resulting from striking the stream bottom. If the trap was found caught on the stream bottom in the morning, the fish captured in the screw trap were documented but were not counted in weekly catch-per-unit-effort calculations and the sampling period for that day was deleted.

During the high-flow spring run-off period, the screw trap was checked twice daily to remove debris and maintain effective trap operation. Flows had subsided by early July allowing a once daily trap check. Starting in early August when bull trout and redband trout (*O. mykiss gairdneri*) catch was low, the trap was checked every one to two days to allow for more intensive fish tracking effort.

All bull trout were measured to the nearest millimeter (mm) fork length (FL) and weighed to the nearest gram (g). Scale samples were collected from all bull trout $\geq$ 100mm FL. All scales collected in 1998 were analyzed by the Oregon Department of Fish and Wildlife (ODFW). The results of the 1998 scale analysis are presented in this report. The ODFW will also analyze the bull trout scale samples collected in 1999. All bull trout $\geq$ 150 mm FL were tagged with passive integrated transponder (PIT) tags in the dorsal muscle just beneath the skin and below the dorsal fin. All bull trout measured, tagged and sampled for scales and genetic tissue were anesthetized with MS-222 (tricaine methanesulfonate).

Subadult bull trout trapping efficiency was determined by PIT tagging all bull trout and then released approximately 460 meters (1500 ft) upstream at the ford crossing once they had recovered from the anesthetic. The ford crossing provide shallow pool conditions for released fish to fully recover. All bull trout captured by screw trap were large enough to receive a PIT tag. A small fin-clip on the upper caudal lobe provided tissue for genetic analysis but also served as a secondary mark incase the PIT tag was expelled or not detected. The screw trap efficiency protocol was not initiated until June 07, 1999. So, immediately after capture and recovery, 10 bull trout were tagged but released downstream of the trap between June 03, 1999 and June 06, 1999.

The date, time (24 hour clock), observed weather conditions and water temperature were recorded each time the screw trap was checked. Water temperature was measured with a hand-held mercury thermometer at the location of the screw trap. Malheur River North Fork discharge in 1998 and 1999 was monitored approximately 0.4km upstream from Beulah Reservoir by a Bureau of Reclamation operated gauging station which provides hourly updates on discharge and temperature**.**

All figures were created by Microsoft Excel 97 as were all statistical analysis. Screw trap efficiency was calculated using the procedure described in Thedinga et al. (1994). The total number of bull trout that passed by the trap was calculated using trap the over-all trap efficiency as described in Roper and Sarnecchia (1999). Ninety-five % confidence intervals were calculated using the formula for the variance of a proportion. The formula is $p$ = +/- $Z_{\alpha/2}$ square root ($pq/N$ ) where p = proportion, q =1-p, N = sample size (Hawkins, 1994; Seelbach et al., 1985). All word processing was performed in Microsoft Word 97. Discharge graphs illustrating 1998 and 1999 daily discharge

data provided by the Bureau Of Reclamation were scanned from hard copies and enhanced with Correll paint.

## Results

During the period of sampling, the downstream migration pattern of Malheur North Fork bull trout in 1999 occurred almost entirely in June and into the early part of July (Weeks 1 to 4). See figure 1 on page 36.

Of a total 61 bull trout captured by rotary screw trap in 1999, 57 were caught between June 02, 1999 and July 07, 1999. The number of bull trout captured declined rapidly from 29 individuals in week 1(June 03, 1999 to June 09, 1999) to 2 individuals during week 5 (July 01, 1999 to July 07, 1999). Only 1 subadult bull trout was captured in midsummer, August 10, 1999 and 3 bull trout, including the only adult captured by screw trap in 1999, and two subadults, were captured in the fall. No adults radio tagged in 1998 or 1999 were captured in the screw trap in either 1998 or 1999.

Of the 52 bull trout marked and released upstream of the screw trap, 7 were recaptured, providing a trap efficiency rate of 13%; CI= +/- 5% (see tables 1 and 2 below). Based on the efficiency rate, an approximate estimate of 346 (Range=250-563 individuals) individual bull trout passed downstream of the screw trap during the sampling period in 1999. The estimate was calculated using the following formula:

**Total # unmarked fish / capture efficiency (%)**

**Table 1.** Recaptured subadult bull trout PIT tagged and released upstream of rotary screw trap, date of capture and date of recapture.

| Fish ID (PIT tag code) | Date of Initial Capture | Date of Recapture | # Days to Recapture |
|---|---|---|---|
| 41791d671e | 6/8/99 | 6/9/99 | 1 |
| 417913767f | 6/9/99 | 6/10/99 | 1 |
| 41793e2bf5 | 6/9/99 | 6/10/99 | 1 |
| 41795e0d04 | 6/9/99 | 6/10/99 | 1 |
| 4179204d5b | 6/9/99 | 6/11/99 | 2 |
| 4179390d0d | 6/15/99 | 6/16/99 | 1 |
| 4179383f50 | Unknown-1st tag lost | 6/16/99 | Unknown |

**Table 2.** Summary of bull trout mark-recapture data collected in 1999 at Crane Crossing, North Fork Malheur River by rotary screw trap.

| Total Caught and Released Upstream | Number Recaptured | % Recaptured (trapping Efficiency) |
|---|---|---|
| 52 | 7 | 13 |

Seventeen bull trout were captured after July 7 throughout the summer and early fall of 1998 compared to the 4 captured in 1999 (See figure 2 on page 36). Note that the screw trap was not operational in 1998 until June 23, making comparisons between the two years difficult. The majority of the bull trout downstream migration period in 1999 and more so in 1998 was probably missed. The larger number of bull trout captured in 1998 during the same sampling period (June 23 to October 15 in both 1998 and 1999) suggests that the number of subadult bull trout downstream migrants could have been greater than the number of 1999 downstream migrants.

Based on evening and morning trap checks in June and July, migration of all species generally occurred at night. In the summer and fall, a quick visual check of the live well of the rotary screw trap was occasionally checked in the daytime, and seldom were any fish of any species observed

Age class composition, determined from scale ages of bull trout captured by rotary screw trap at Crane Crossing consisted almost entirely of age 3 and 4 fish, probably subadults. The only exceptions were one subadult fish aged at 2 years, and one other adult, probably a migrant spawner, aged at 6 or 7 years. One adult, which could not be aged precisely due to poor scales, was aged at 3 or 4 years. See table 3 on page 38.

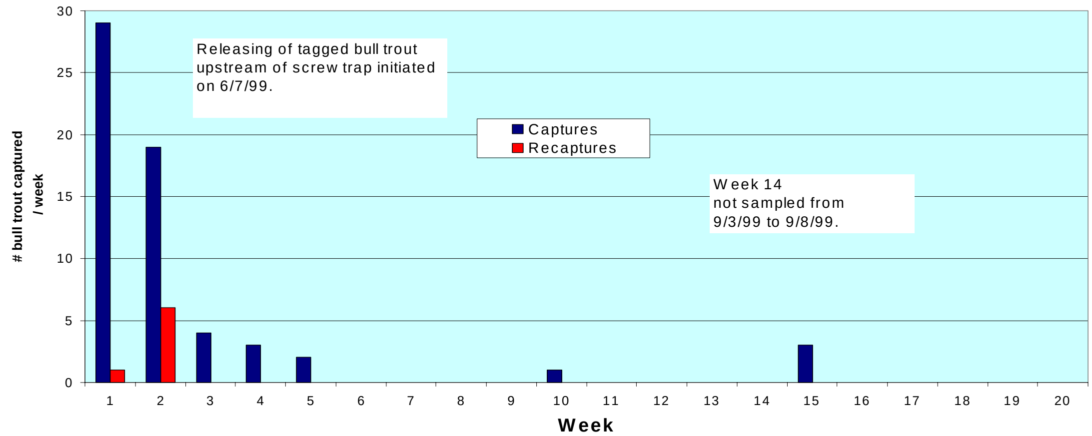


**Figure 1**. Number of bull trout and number of recaptured bull trout caught per week by 5ft diameter rotary screw trap from June 03, 1999 to October 19, 1999, Crane Crossing, North Fork Malheur River, Oregon.

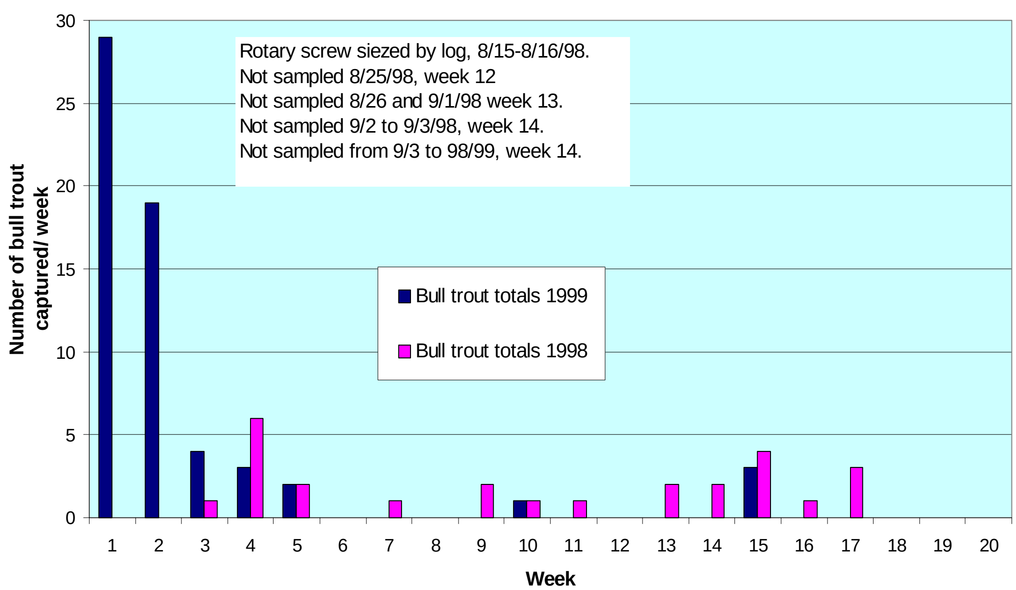


**Figure 2.** Total number of bull trout captured at Crane Crossing by rotary screw trap from June 23,1998 to October 15, 1998 and from June 03, 1999 to October 19, 1999.

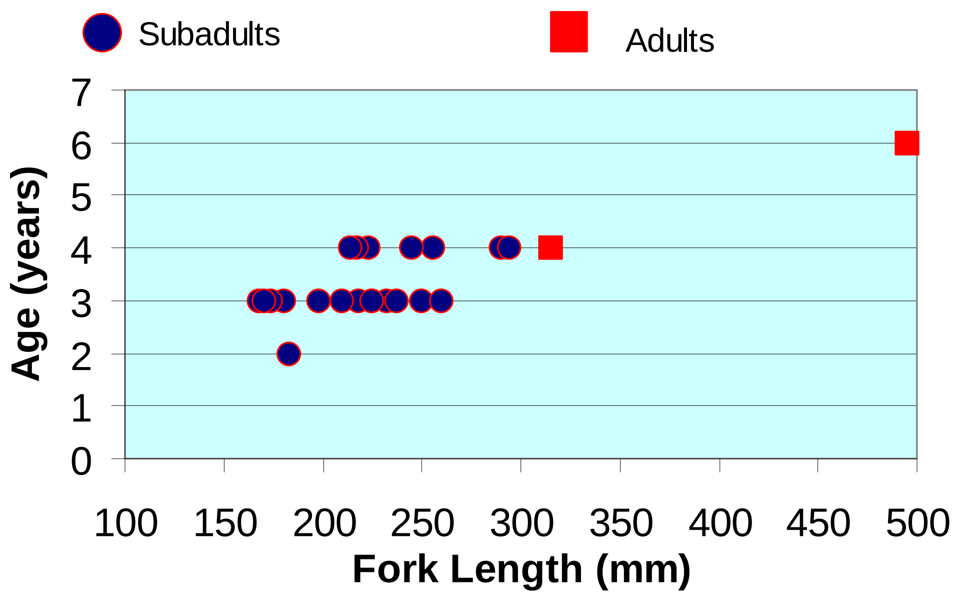


**Figure 3**. Relationship between bull trout age and fork length captured by rotary screw trap in 1998 at Crane Crossing, North Fork Malheur River, Oregon.

**Table 3.** Age class composition of bull trout captured by rotary scredw trap in 1998 at Crane Crossing, North Fork Malheur River.

| | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 3 or 4 | Age 5 | Age 6 or 7 |
|---|---|---|---|---|---|---|---|---|
| Number | 0 | 0 | 1 | 14 | 8 | 1 | 0 | 1 |
| % | 0 | 0 | 4 | 56 | 32 | 4 | 0 | 4 |

There was considerable overlap in forklength between age 3 and 4 fish. Age 3 fish ranged from 168 mm FL to 260 mm FL. Age 4 fish ranged from 214 mm FL – 315 mm FL (see figure on page 37). One age 4 fish, captured on September 23, 1998, measuring 315mm FL, was identified as a ripe female as eggs were observed while it was being measured. The only bull trout aged at 2 years was 183 mm FL.

## Discussion

The number of bull trout captured per week in June 1999 may have been correlated with stream discharge. Stream discharge during the month of June 1999 dropped from 1400 cfs to 200 cfs which compares strikingly to the drop from 300cfs to 100 cfs in June 1998 (see figures 4 and 5 page 39). The numbers of captured bull trout rapidly declined in June with the decline in discharge. By early July, stream discharge appeared to reach base flow conditions during which almost no bull trout were captured. The 1999 spring discharge may have resulted in a rapid flushing of downstream migrating fish. High flows may have assisted the downstream migrating fish to rearing areas with minimum energy expenditure, which would explain the large number of subadult bull trout captured in June with only an occasional fish being captured thereafter. Positive correlations with anadromous smolt outmigration time and discharge have generally been observed in other watersheds. Conversely, Roper and Scarnecchia (1999) found no correlation between wild chinook smolt outmigration and discharge, but observed significant correlations between temperature, lunar phase and photoperiod. Stream temperature may also have affected bull trout downstream migration in the Malheur North Fork. The BOR gauging station located ¼ mile upstream from Beulah Reservoir showed an increase in daily average water temperature in June 1999 from approximately 10$^{o}$C to 16$^{o}$C.

The low discharge in 1998 may have slowed bull trout downstream migration, thus bull trout were occasionally caught throughout the sampling period until mid fall. Since the screw trap cannot be set until enough snow has cleared allowing access to Crane Crossing, correlating stream flow with incomplete bull trout outmigration data cannot produce definitive results. Bull trout downstream migration in 1998 may have been more gradual as a result of the much lower discharge. Bull trout captured in 1998 were significantly larger than the bull trout captured in 1999 (Tiley, 2000b), suggesting that bull trout movement in 1998 was slower allowing for more growth before reaching the screw trap just below Crane Crossing.

The decline in bull trout captures as flow declined was probably related to seasonal migration behavior than to changes in trap efficiency. Roper and Scarnecchia (1996) found that hatchery chinook salmon (*Onchorhynchus tshwaytcha*) capture efficiency by rotary screw trap decreased with a decrease in flow in the South Umpqua River and observed that hatchery produced chinook smolts had a greater difficulty in avoiding capture during high flows under daylight conditions. The hatchery chinook, which migrated downstream primarily in day light, were observed turning to face down stream in the slower sections of pools with many avoiding the screw trap in the process. Wild chinook migrated almost entirely during the dark hours with capture efficiency remaining constant despite a gradual decline in flow conditions (Poper and Scarnecchia, 1996). Since it is known that bull trout movement occurs primarily at night, it seems unlikely that the decline in captured bull trout with a decline in flow was related to an increase in avoidance of the screw trap.

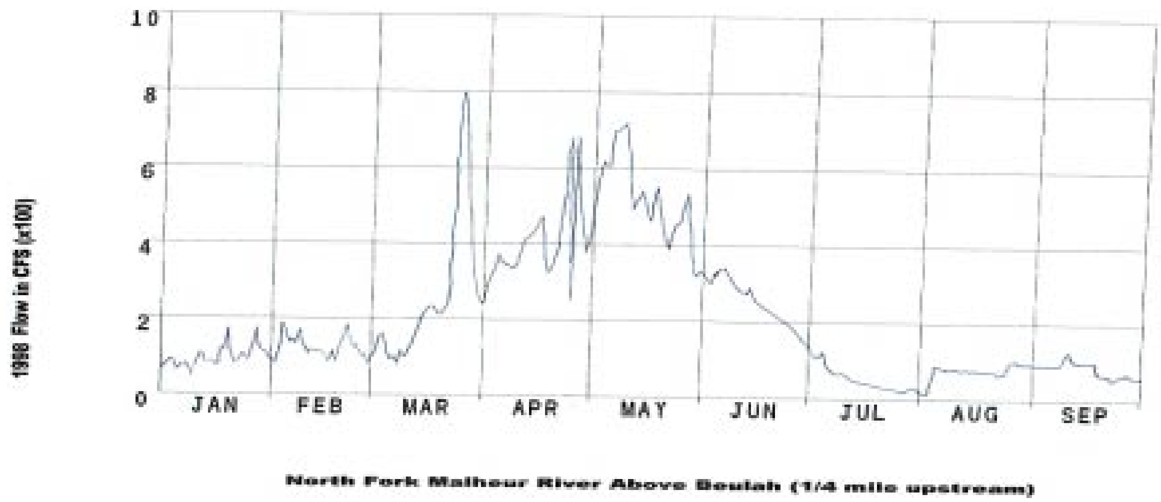


**Figure 4.** North Fork Malheur River discharge data gathered in 1998 by the Bureau Of Reclamation flow gauging station above Beulah Reservoir plotted against time.

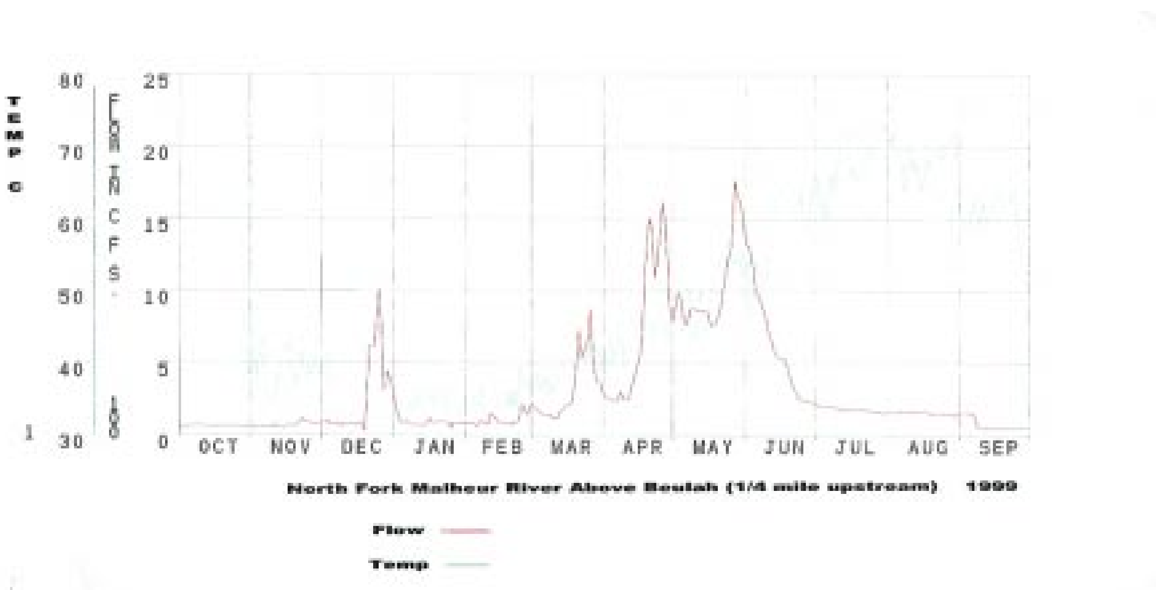


**Figure 5.** North Fork Malheur River discharge and temperature data gathered in 1999 by the Bureau Of Reclamation flow gauging station above Beulah Reservoir plotted against time.

Thedinga et al. (1994) found that intermediate size groups of chinook, coho (*O.kisutch*) and sockeye salmon smolts (*O.nerka*) but not steelhead smolts, had a higher probability of capture by screw trap. A combined total of 3 bull trout over 300 mm FL were captured in 1998 and 1999. All 24 radio tagged adult bull trout known to have emigrated downstream of Crane Crossing in the fall successfully avoided capture, suggesting that the larger bull trout can easily avoid capture by screw trap under fall discharge conditions. However, redd counts indicate that the adult bull trout migratory component is small in the North Fork Malheur relative to bull trout populations in other parts of Oregon; thus, the extremely low frequency of capture may simply have been a reflection of the small population size.

The observed over-all screw trap efficiency of 13% was similar the screw trap efficiencies observed for other studies on salmonid outmigration which ranged from 3% to 33% (Roper and Scarnecchia, 1999; Roper and Scarnecchia, 1996; Thedinga et al. 1994,Tiley 2000c), indicating that our sampling was effective in capturing a large enough sample size to obtain valid trap efficiency and population estimates. However, variability in trap efficiencies has been observed between species, age classes, and environmental conditions. The lack of screw trap efficiency data specifically related to bull trout limits our knowledge of the effectiveness of our sampling and our ability to make comparisons to other studies.

Comparisons between the number of downstream migrating bull trout captured in 1998 vs 1999 is difficult because the screw trap was not operating until June 23 in 1998. The noticeably larger number of bull trout captured after June 23 in 1998, compared to the number of bull trout captured in 1999 may have simply been a reflection of what might have been a larger overall number of downstream migrants in 1998. Also, efficiency of the screw trap probably varies with water level and stream velocity. The lesser flows observed in 1998 throughout the summer may have increased trapping efficiency as a higher percentage of stream cross-sectional area would have been sampled. Thunderstorms were much more frequent in 1998 than in 1999 (Schwabe, personal communication) which may have affected bull trout movement.

Three bull trout were captured during week 15 (September 02, 1999 to September 08, 1999) which might suggest a small fall downstream migration, a migration that may have been more prominent in the data had the screw trap been operating for the entirety of week 14. One bull trout that was captured in the screw trap on 8/18/98 (PIT code 50150B0E37) and was later recaptured in the Beulah Reservoir on 4/20/99. Possibly this bull trout was one of a larger fall bull trout downstream migration. A telemetry study on the migratory behavior of subadult bull trout would provide useful information such as duration and extent of downstream migration, rearing habitat requirements and seasonal movements. It is hoped that a juvenile bull trout migration behavior study, using 2.0g to 3.6g radio tags or Lotek Nanotags, will be initiated in 2001 or 2002.

Age class structure of subadult bull trout captured in the screw trap suggested that the majority of North Fork Malheur River fluvial/adfluvial bull trout rear in natal or headwater tributaries for 3 to 4 years before migrating to higher order streams or the Beulah Reservoir. The headwaters of the North Fork Malheur River remain relatively cold year round (ie range $7^{o}C$ to $12^{o}C$ during summer) (Perkins, 1999) which appear to be necessary for young of year and juvenile bull trout survival and growth (Buchanan and Gregory, 1997). Malheur North Fork fluvial bull trout may have to grow for three to four years before they can tolerate the warmer temperatures of the Malheur mainstem or become competitive with other species such as redband trout.

## Acknowledgements

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# Length-Weight Relationships of bull trout in the North Fork Malheur River, Oregon.

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## Introduction

Length and weight data provide essential information on size distribution, length at age, growth, and condition, which are invaluable information for fishery management and research (Anderson & Neumann, 1996). With the long-term objective of achieving a complete understanding of the life history of Malheur River bull trout (*Salvelinus confluentus*) and the health of the population, length and weight data were analyzed to determine differences in condition factor between years, relationships between capture locations and condition factor, and length at age at a given location (see chapter 1c for length at age relationships). The objectives of the following analysis were as follows:

(a) Identify possible relationships between condition factor, time of capture, and habitat.
(b) Identify possible effects of entrainment on bull trout condition downstream of Agency Valley dam.

(c) Describe mathematically the relationship between bull trout length and weight for the North Fork Malheur River population.
(d) Calculate growth of recaptured bull trout.

This investigation is preliminary as the length-weight relationships of the North Fork bull trout population will later be compared to the Malheur River Middle Fork population following FY 2000. Furthermore it is expected that a bull trout subadult migration study will begin in the North Fork in 2001 or 2002 whereby additional data, particularly in regard to mark-recapture, will be available. Also, it is the intent of the author to compare the condition factor of the Malheur River bull trout populations to other bull trout populations in Oregon to determine differences in life-history and length-weight characteristics.

## Methods

All bull trout sampled in the upper Malheur River system that were measured and weighed were sorted according to sampling location, date of capture and sampling method. Generally all bull trout were measured and weighed on the date and time of capture. Bull trout angled below the Agency Valley Dam at Beulah Reservoir were kept alive in a bucket supplied with a constant flow of fresh water until a biologist certified in radio tag implant surgery procedures could implant radio tags into the bull trout. Surgeries were usually performed a few hours after capture, and never longer than 24 hours. These fish that were angled below the reservoir were measured and weighed immediately prior to the surgery. Only bull trout measured by fork length (FL) to the nearest millimeter (mm) and to the nearest gram (g) were included in the analysis. Condition factor was calculated using the Fulton Condition Factor equation $W/L^3 x100, 000$.

All statistical analysis and calculations were performed in Microsoft Excel. Students' *t*-tests were used to compare condition factors between entrained bull trout trapped below the Agency Valley Dam in spring 1999 and bull trout captured in Beulah Reservoir in spring 1999. Regression and $R^2$ values were used to test for relationships between date of capture and condition factor. An exponential equation and $R^2$ value was used to calculate the relationship between bull trout length and weight.

## Results

### **Subadult bull trout length relationships Crane Crossing, 1998 and 1999.**

Almost all bull trout captured at Crane Crossing by rotary screw trap in 1999 were captured in June. Bull trout captured by Rotary screw trap in 1998 were captured throughout the season with a slightly higher capture frequency in late summer/early fall (Tiley, 2000a), figure 1 below.  Mean fork length

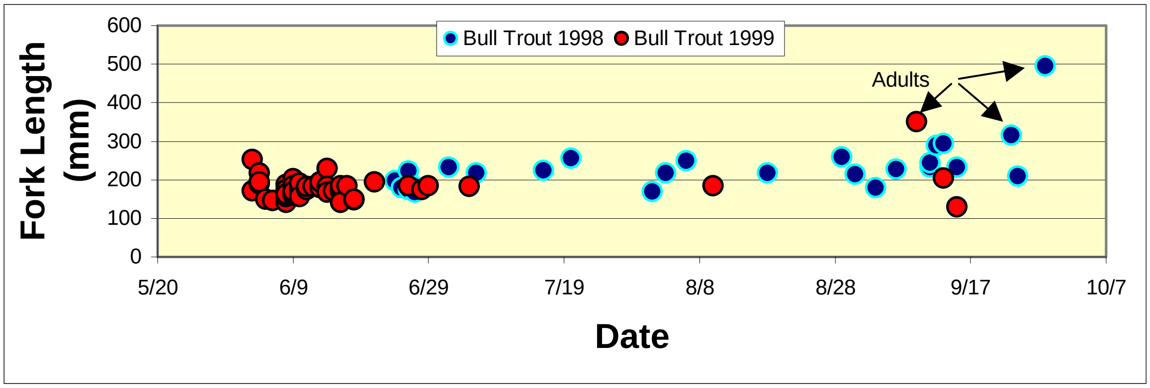


Figure 1. Bull trout fork length VS date of capture by 1.52 m (5 ft) diameter rotary screw trap in 1998 and 1999, Crane Crossing, Malheur National Forest, Oregon.

of bull trout captured by screw trap in 1998 were significantly larger than bull trout captured by screw trap in 1999 (*t*-test; $p<0.0001$). See figure 1 above and table 1 below. Statistical analysis comparing weight and condition factor between bull trout captured in 1998 and 1999 by rotary screw trap was not performed because of the small sample size (n=11) of fish weighed in 1998. However the data presented in table 1 below, suggests that the bull trout captured in 1998 were in better condition than bull trout captured in 1999.

**Table 1.** Fork length, weight and condition factors of bull trout (*Salvelinus confluentus*) captured by 1.52 m diameter rotary screw trap in 1998 and 1999 at Crane Crossing, North Fork Malheur River, Oregon.

| | 1999 Subadult bull trout fork length (mm) | 1998 Subadult bull trout fork length (mm) | 1999 Subadult bull trout weight (g) | 1998 Subadult bull trout weight (g) | 1999 Subadult bull trout condition factor | 1998 Subadult bull trout condition factor |
|---|---|---|---|---|---|---|
| **min** | 141 | 168 | 26 | 48 | 0.79 | 0.72 |
| **max** | 253 | 294 | 151 | 192 | 1.24 | 1.53 |
| **mean** | 179 | 224 | 59 | 99 | 0.98 | 1.04 |
| **stdev** | 23 | 40 | 25 | 42 | 0.09 | 0.20 |
| **n** | 52 | 23 | 52 | 11 | 52 | 11 |

The length-weight relationship of North Fork Malheur River bull trout is defined by the exponential equation $y=0.000007x^{3.0668}$ whereby x = fork length and y = weight. Ninety-nine percent of the variation in weight can be explained by fork length ($R^2 = 0.9899$). See figure 2 below. Ten out of Thirteen bull trout (77%) captured by angling below the Agency Valley Dam fell below the length-weight equation line. A comparison of condition factor indicated a significant difference (*t*-test, $p<0.05$) between bull trout captured in the Beulah Reservoir in 1999 vs bull trout captured downstream of the Agency Valley Dam in 1999.

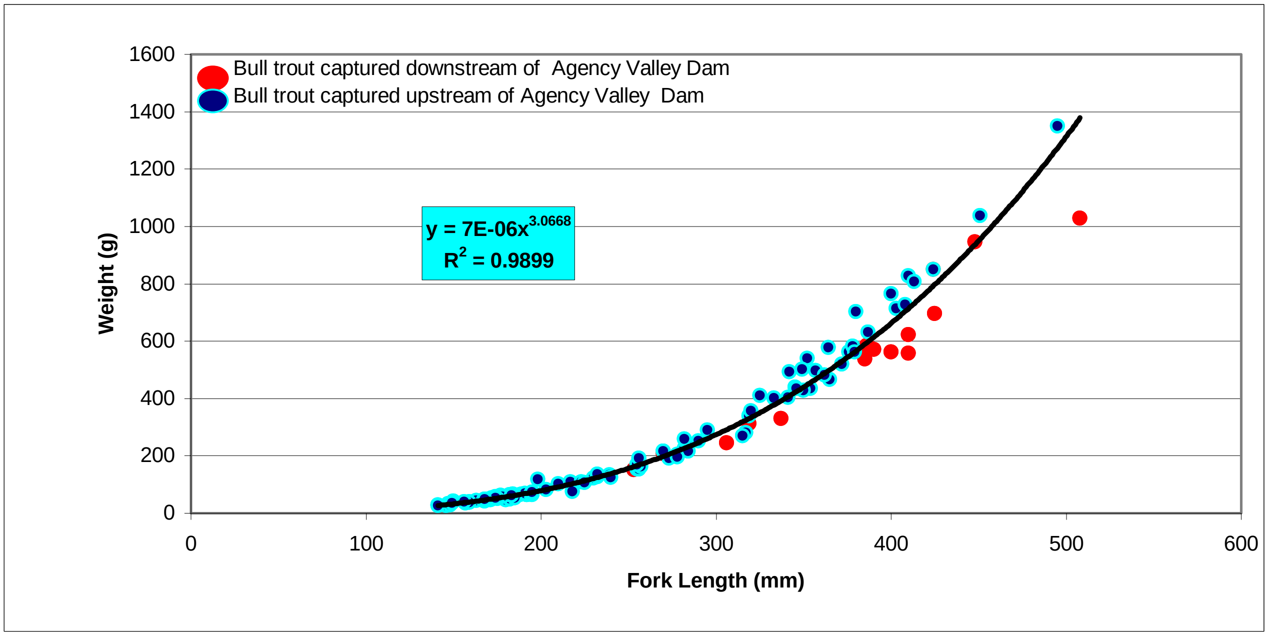


**Figure 2.** Length-weight relationship of bull trout captured in the spillway below the Agency Valley Dam and upstream of the Agency Valley Dam in 1998 and 1999 in the North Fork, Malheur River, Oregon.

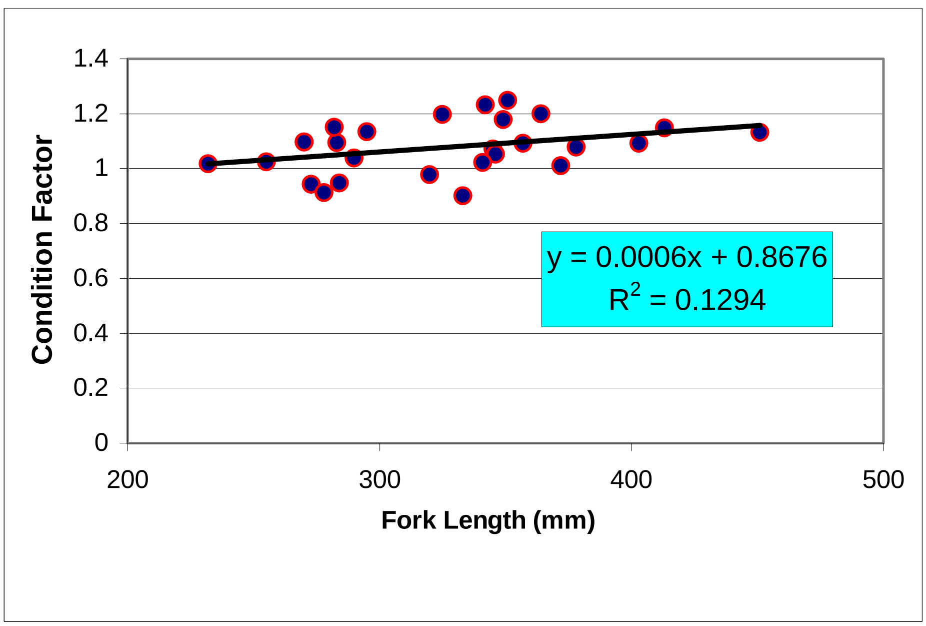


**Figure 3.** Relationship between bull trout fork length and condition factor of bull trout captured in Beulah Reservoir, Oregon, in 1998.

Bull Trout Condition factor of bull trout captured in the Beulah Reservoir in 1998 and 1999 were plotted against fork length. Avery slight positive relationship was evident between bull trout bull trout fork length and Fulton condition factor (y=0.0006x + 0.867; $R^2$ = 0.1294). See figure 3 above. A much more noticeable, but still weak relationship (y=0.0014x+0.5801; $R^2$ = 0.515) was observed between bull trout condition factor and fork length in 1999. See figure 4 below.

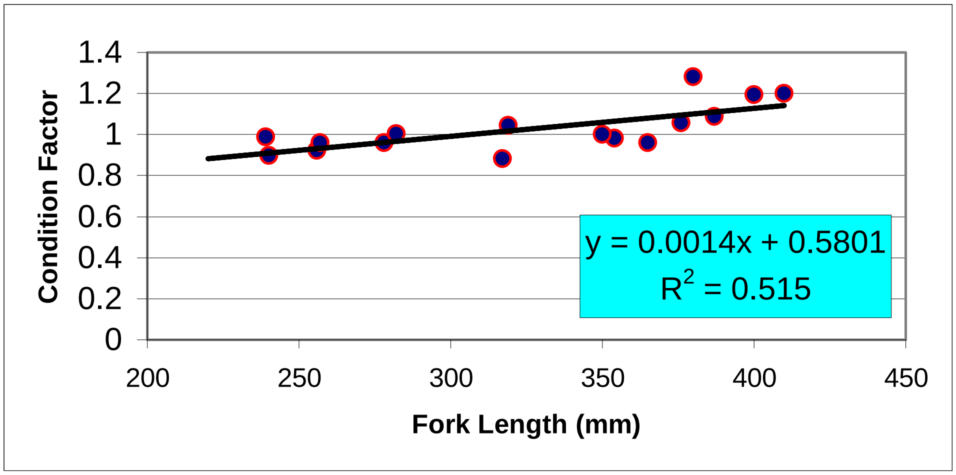


**Figure 4.** Bull trout Fulton Condition Factor in relation to fork length from bull trout captured in the Beulah Reservoir, Oregon, in 1999.

Adult bull trout typically migrate upstream out of Beulah Reservoir to the headwaters of the Malheur North Fork River between late March and June (Gonzalez et. al. 1999; Schwabe, 2000) eventually to spawn in late summer or early fall (Perkins, 1999; Gonzalez et al. 1999; Schwabe, 2000). However, many radio tagged adult bull trout reached the mouths of spawning tributaries weeks and in some cases months before ascending spawning tributaries (Schwabe, 2000). Bull trout may therefore leave Beulah Reservoir to avoid rapidly increasing water temperatures and decreasing dissolved oxygen concentrations that were observed by the Bureau of Reclamation in 1999 (Zimmer, unpublished data). Bull trout Fulton Condition Factor was therefore regressed against time as a decline in bull trout condition factor might suggest limiting habitat conditions for bull trout in the Beulah reservoir. Bull trout condition was not found to be related to the date of capture represented in days in either 1998 or 1999, see figures 5 and 6 below.

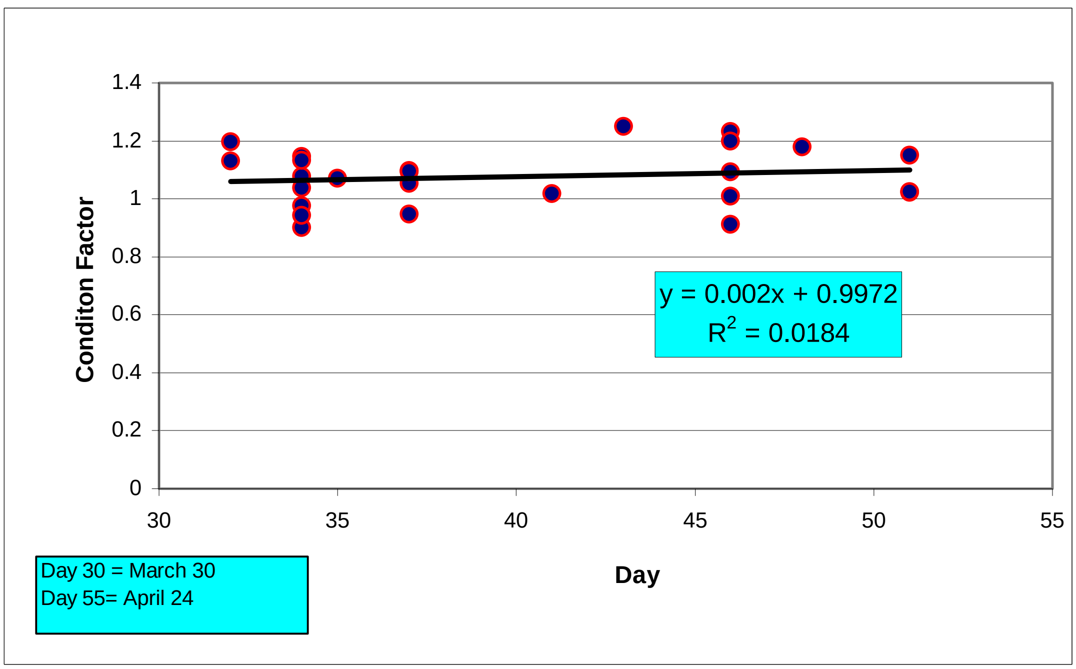


**Figure 5.** Relationship between bull trout condition factor and date of capture in the Beulah Reservoir, Oregon, March and April 1998.

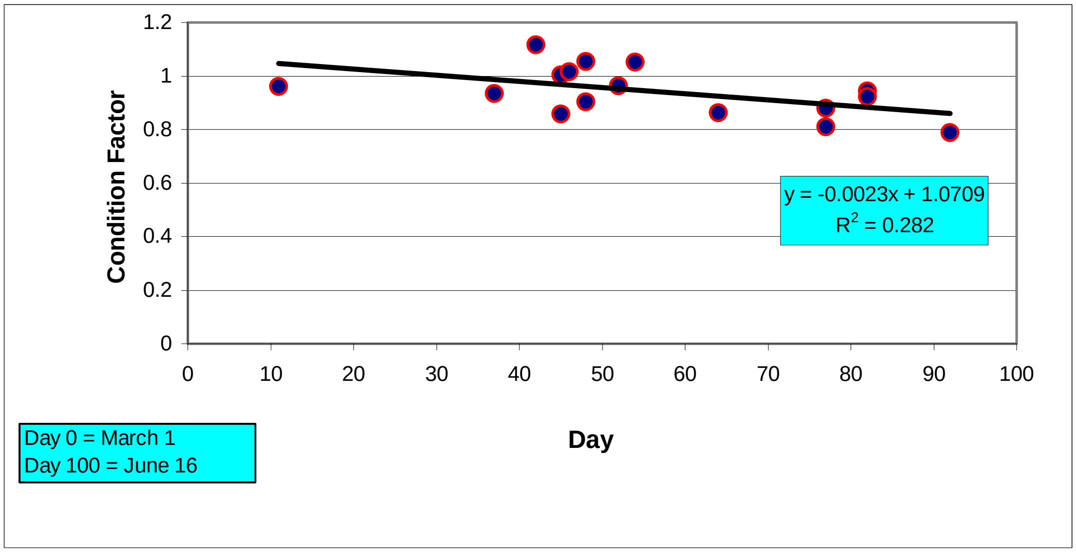


**Figure 6.** Relationship between bull trout condition factor and date of capture in the Beulah Reservoir, Oregon, March and April 1998.

A small sample of four radio tagged adult bull trout were recaptured which provided information on growth and condition. Tables 2 to 5 summarize the recapture data for each individual fish. Three of the four radio tagged fish were recaptured in Beulah Reservoir where the old radios used in 1998 were replace with new ones in 1999; thus these fish are identified by two radio frequencies.

Growth rate was greatest in bull trout 151.513 at 0.53mm/day but showed a small, possibly negligible, decrease in condition (-0.04). 151.513 was recaptured in summer 1998; the season when temperatures are higher and food resources typically more abundant, which may explain the relatively rapid increase in length. The other three fish recaptured in April 1999 had just recently overwintered, so their growth rate was probably slowed as a result of lower prey availability and colder temperatures.

Bull trout 151.803/150.922, which was recaptured in July 1998, showed the greatest increase in fork length compared to the other bull trout that were captured early in the spring of 1999, suggesting that a decline in growth rate occurs during winter. Bull trout 151.463/151.133 had the greatest increase in weight and also had the only net positive increase in condition factor (0.19). The greatest decline in Fulton Condition Factor was observed for bull trout 151.582/151.192 (-0.12).

**Table 2.** Bull Trout PIT tag identification, growth period and capture/recapture locations of recaptured bull trout in the Malheur River upstream of the Beulah Reservoir Dam, Oregon, 1998 and 1999.

| Radio Frequency 1998 and 1999 | PIT tag | Growth Period (days) | Initial capture and Recapture dates | Location of initial capture | Location of recapture |
|---|---|---|---|---|---|
| 151.513 (1998) | 50151b3743 | 66 | 4/5/1998 to 7/10/98 | Beulah | Crane Crossing |
| 151.803, 150.922 | 50150C7210 | 357 | 4/16/1998 to 4/8/99 | Beulah | Beulah |
| 151.582, 151.192 | 50151A2107 | 357 | 4/18/1998 to 4/10/99 | Beulah | Beulah |
| 151.463, 151.133 | 4179503614 | 352 | 4/3/1998 to 4/16/99 | Beulah | Beulah |

**Table 3.** Bull trout length, weight and Fulton Condition Factor data obtained from four radio tagged bull trout recaptured in the Malheur North Fork system upstream of the Agency Valley Dam, Oregon, in 1998 and 1999.

| Radio Frequency 1998 and 1999 | Initial capture Length (mm) | Recapture Length (mm) | Net increase (mm) | Growth Period (days) | Growth Rate (mm/day) | Percent increase in body length Length i /growth) |
|---|---|---|---|---|---|---|
| 151.513 (1998) | 345 | 379 | 34 | 66 | 0.52 | 9.86 |
| 151.803, 150.922 | 372 | 400 | 28 | 357 | 0.08 | 7.53 |
| 151.582, 151.192 | 349 | 376 | 27 | 357 | 0.08 | 7.74 |
| 151.463, 151.133 | 333 | 386 | 53 | 352 | 0.15 | 15.92 |

**Table 4.** Bull trout growth rate of recaptured radio tagged adults in the North Fork Malheur River upstream of Agency Valley Dam.

| Radio Frequency 1998 and 1999 | Initial capture Weight (g) | Recapture Weight (g) | Net increase Weight (g) | Growth Period (days) | Growth Rate (g/day) | Percent increase in body Weight (Weight1/growth) |
|---|---|---|---|---|---|---|
| 151.513 (1998) | 440 | 562 | 114 | 66 | 1.73 | 25.91 |
| 151.803, 150.922 | 520 | 765 | 234 | 357 | 0.66 | 45.00 |
| 151.582, 151.192 | 501 | 562 | 50 | 357 | 0.14 | 9.98 |
| 151.463, 151.133 | 401 | 584 | 175 | 352 | 0.50 | 43.64 |

**Table 5.** Change in adult radio tagged bull trout Fulton condition factor recaptured upstream of the Agency Valley Dam.

| Radio Frequency 1998 and 1999 | Initial capture Fulton Condition Factor | Recapture Fulton Condition Factor | Net difference Fulton Condition Factor |
|---|---|---|---|
| 151.513 (1998) | 1.07 | 1.03 | -0.04 |
| 151.803, 150.922 | 1.01 | 1.2 | 0.19 |
| 151.582, 151.192 | 1.18 | 1.06 | -0.12 |
| 151.463, 151.133 | 1.09 | 1.02 | -0.07 |

## Discussion

The greater average in bull trout fork length captured in 1998 vs 1999 is probably attributable to growth, whereby the larger number of bull trout captured in the summer and fall of 1998 had achieved a greater weight that the bull trout captured in the spring of 1999. Year-to-year variation in age composition of downstream migrants, habitat quality and prey abundance may also have been significant factors. The ODFW will analyze scales collected in 1999 so that comparisons can be made between the age composition of bull trout captured in 1998 and 1999. There is currently no intention to monitor habitat quality and prey availability in the North Fork Malheur River that would provide correlations between bull trout condition factor with habitat quality and prey availability. The limited accessibility into the North Fork Malheur River by road in late May and early June would make such a study difficult to implement at this point.

The lower Fulton Condition Factor of bull trout captured below the Agency Valley Dam was probably an indication of poorer habitat quality and a lower availability of food resources. Large numbers of rainbow/ redband trout were observed immediately below the Agency Valley Dam spillway probably competed for food and holding positions with the entrained bull trout.

The bull trout captured below the Agency Valley Dam were held in a holding tank without food for up to 24 hrs prior to surgery, so it is unknown if a significant amount of weight-loss occurred during the holding period that may have caused the significant difference in condition factor between entrained fish and fish captured in the reservoir. Bull trout captured in the reservoir were measured and weighed immediately prior to undergoing surgery which was always within 30 minutes of initial capture. Weights and lengths of bull trout angled below the Agency Valley Dam in the year 2000 will be measured immediately after capture, then held for approximately 24 hours (hr) and measured and weighed again to determine the effects of a 24 hr food deprivation period on bull trout condition.

Of the five radio-tagged bull trout that were released below the Agency Valley Dam, three radios were recovered in the fall of 1999 and the fish were presumed to have died. One tag disappeared 3 weeks after it was tagged. The one radio tag that was still active when this report was written has not moved since the fall of 1999 and we suspect that the bull trout died. Our tracking and condition factor data suggests that bull trout habitat and survival rate below the Agency Valley Dam is poor. The causes of bull trout mortality below the Agency Valley Dam is unknown. Angling pressure is heavy below the Agency Valley dam spill way (personal observation) where bait fishing is still legal (ODFW, 1999, 2000). Angling below the Agency Valley Dam by the Burns Paiute Tribe Fish and Wildlife staff and recreational anglers was highly successful in capturing many of the bull trout that were later used for radio tagging in 1999. The five radio-tagged bull trout released below the Agency Valley Dam may therefore have succumbed to angler induced predation, injury, or stress.

The limited sample sizes and limited time sampled may have not been extensive enough to detect a decline in condition factor over time within Beulah Reservoir. The majority of radio tagged adults captured in Beulah Reservoir generally migrated out of the Reservoir soon after peak flows began to subside (personal observation) during a period when reservoir temperatures ranged from 8.1$^{o}$C – 13.4$^{o}$C and dissolved oxygen levels ranging from 8.1 mg/l – 13.4 mg/l (BOR, unpublished data): conditions easily able to support subadult and adult bull trout (Buchanan & Gregory, 1997). However, Beulah Reservoir water quality rapidly declined with water temperature in excess of 20$^{o}$Cand dissolved oxygen levels lower than 5mg/l in water cooler than 20$^{o}$Cduring the spring and summer of 1999 (Zimmer, unpublished data). If bull trout remain in Beulah reservoir during the spring and summer, their condition factor may decline along with the decline in habitat quality.

It is difficult to determine whether the observed changes in condition factors of recaptured bull trout were significant with such a limited sample size. Bull trout life history research is expected to resume in the North Fork Malheur in 2001 or 2002 where it is hoped many more radio tagged and PIT (passive integrated transponder) tagged fish will be recaptured. The recapture data does indicate that radio tagged bull trout can continue to feed effectively. Current work on the Middle Fork Malheur River may enable us to compare growth and survival rate between PIT tagged bull trout and radio tagged bull trout ranging in 120g to approximately 1000g in weight. Such a comparison may show the effect a radio tag has on the ability of bull trout to compete and reproduce.

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## Bull Trout Spawning Surveys 1999

### Objective

The purpose of this project is to determine where and when spawning occurs and try to estimate the abundance of the spawning population.

### Methods

In 1999, crews walked the survey sections three times August 31st, September 1st and 2nd, on September 14th-16th, and on September 28th-30th. Surveys were walked in an upstream direction. Survey starting points, ending points, redds, and bull trout locations were recorded with hand held GPS receivers, marked on 7.5‘ quad maps, and were flagged for future reference. GPS coordinates were entered into GIS and mapped. Locations were corrected by moving them to stream in either a north/south or east/west direction. The distance moved and direction were recorded. All stream section lengths from all years were measured using GIS software so all lengths changed again, but should be correct now.

### Results

North Fork Malheur River

The stream section on upper North Fork (Figure 1) was surveyed three times in 1999. It began at the mouth of Deadhorse Creek and ended upstream at the headwater spring. Three redds and 11 bull trout were observed in the North Fork during the August 31st survey, five redds and 3 bull trout were observed September 14th survey, and one redd was observed in the North Fork during the September 28th survey.

Table 5. Bull trout redds observed in the mainstem of the North Fork Malheur River, 1992-99.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992[a] | 1 | 5.9 | 0.2 |
| 1993 | 1 | 15.5 | 0.1 |
| 1994 | 0 | 7.3 | 0.0 |
| 1995 | 0 | 6.0 | 0.0 |
| 1996 | 6 | 3.9 | 1.5 |
| 1997 | 10 | 2.3 | 4.4 |
| 1998 | 3 | 3.8 | 0.8 |
| 1999 | 9 | 3.5 | 2.6 |

[a]- Does not includes 14 questionable redds observed by volunteers.

Horseshoe Creek

The stream section on Horseshoe Creek was surveyed three times in 1999 (Figure 1). This year the survey area was extended upstream an additional 0.4 miles beyond the 1998 section. The 3 to 4 foot barrier observed at the end of the 1998 section was no longer present.

No redds were observed during the August 31st survey (Table 6). Two redds were observed during each of the September 14th and September 28th surveys. Bull trout were observed but it was difficult to determine whether they were in the Horseshoe Creek or North Fork from the data sheets.

Table 6. Bull trout redds observed in Horseshoe Creek, 1998-99.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 4 | 0.4 | 10.0 |
| 1999 | 4 | 0.8 | 5.0 |

Deadhorse Creek

The lower 0.7 miles of Deadhorse Creek was walked during the second survey period. No redds or bull trout were observed (Figure 1).

Flat Creek

The lower 0.4 miles of Flat Creek was walked during the first survey period. No redds or bull trout were observed.

Swamp Creek

Both sections of Swamp Creek were surveyed three times in 1999 and both sections were very similar to sections walked in past years (Figure 2).

Eleven redds and 25 bull trout were observed during the August 31st survey. Twenty-two new redds and 23 bull trout were observed on the September 14th survey. Two new redds and zero bull trout were observed during the September 28th survey (Table 7).

Table 7. Bull trout redds observed in Swamp Creek, 1992-99.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 0 | 1.2 | 0.0 |
| 1993 | 3 | 2.2 | 1.4 |
| 1994 | 9 | 3.9 | 2.3 |
| 1995 | 0 | 3.9 | 0.0 |
| 1996 | 8 | 3.8 | 2.1 |
| 1997 | 21 | 4.1 | 5.1 |
| 1998 | 24 | 4.2 | 5.7 |
| 1999 | 35 | 4.1 | 8.5 |

Sheep Creek

The stream section was surveyed three times. This year it began at the mouth and ended 3.8 miles upstream which was about 1/4 mile longer than 1998 (Figure 2). In the future, the survey section will be broken into two sections at about stream mile 2 and cover the same distance surveyed in 1999. This would make it easier to walk the upper end of this stream section.

Five redds and 24 bull trout were observed during the August 30th survey. Fourteen new redds and 11 bull trout were observed during the September 14th survey. Three new redds and 8 bull trout were observed during the September 28th survey (Table 8).

Table 8. Bull trout redds observed in Sheep Creek, 1992-99.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 0 | 1.1 | 0.0 |
| 1993 | 0 | 2.2 | 0.0 |
| 1994 | 0 | 2.2 | 0.0 |
| 1995 | 2 | 2.9 | 0.7 |
| 1996 | 13 | 3.4 | 3.8 |
| 1997 | 8 | 2.9 | 2.8 |
| 1998 | 17 | 3.5 | 4.9 |
| 1999 | 22 | 3.0 | 7.3 |

Elk Creek

This stream section was walked three times in 1999 (Figure 3). Five redds and 10 bull trout were observed during the August 30th survey. Seven new redds and 5 bull trout were observed during the September 14th survey.  Zero new redds and three bull trout were observed during the September 28th survey (Table 9).

Table 9.  Bull trout redds observed in Elk Creek, 1992-99.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 1 | 1.0 | 1.0 |
| 1993 | 1 | 2.3 | 0.4 |
| 1994 | 0 | 2.0 | 0.0 |
| 1995 | 1 | 4.0 | 0.3 |
| 1996 | 3 | 4.1 | 0.7 |
| 1997 | 9 | 4.1 | 2.2 |
| 1998 | 6 | 3.5 | 1.7 |
| 1999 | 12 | 3.0 | 4.0 |

Crane Creek

Crane Creek was not surveyed in 1999 and probably will not be surveyed in the future.

Little Crane Creek

Both sections of Little Crane Creek were surveyed three times this year.  Both sections similar to past years (Figure 4).

Ten redds and 37 bull trout were observed during the August 31st survey.  Nineteen new redds and 39 bull trout were observed during the September 14th survey.  Four new redds and 19 bull trout were observed during the September 28th survey (Table 10).

Table 10.  Bull trout redds observed in Little Crane Creek (1992-99).

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | | | |
| 1993 | 3 | 5.6 | 0.5 |
| 1994 | 4 | 7.5 | 0.5 |
| 1995 | 6 | 6.0 | 1.0 |
| 1996 | 8 | 6.0 | 1.3 |
| 1997 | 16 | 4.2 | 3.8 |
| 1998 | 20 | 6.0 | 3.3 |
| 1999 | 33 | 6.1 | 5.4 |

Livestock Observations

In 1999, livestock were observed in or near several survey sections. Along Swamp Creek about 140 sheep were observed in and around the channel. Surveyors had to skip part of the survey because sheep had muddied the water. Along Little Crane Creek no livestock were seen below Forest Road 16. Upstream of the 16 road, no livestock were present during the August 31st survey. During the second pass on September 14th several cows were found inside an electric fence around a downstream area of the creek. During the third pass on September 28th one redd was observed with cow hoof prints in the pot and several redds observed during earlier passes had been trampled by cows. No livestock observations were noted for Sheep Creek. No livestock observations were noted on the data sheet for Elk Creek, but several head of cows were observed very near the stream with some hoof prints in and along Elk Creek. No livestock observations were noted for the surveys on the North Fork Malheur River and Horseshoe Creek.

## Bull Trout Observations

This year for the first time all crews counted and located most of the observed bull trout while completing the spawning surveys (Table 11). There appeared to be a decrease in the number of fish observed between the surveys.

Table 11. Number and average estimated length of bull trout observed during the three spawning surveys on North Fork Malheur River streams in 1999.

| | **Aug. 31st Survey** | | **Sep. 14th Survey** | | **Sep. 28th Survey** | | |
|---|---|---|---|---|---|---|---|
| **Stream** | **N** | **Avg. Length** | **N** | **Avg. Length** | **N** | **Avg. Length** | **Total** |
| **Swamp Cr.** | 25 | 11” | 23 | 10” | 0 | | 48 |
| **Little Crane Cr.** | 37 | 10” | 39 | 8” | 19 | 8” | 95 |
| **Sheep Cr.** | 24 | 8” | 11 | 9” | 8 | 10” | 43 |
| **Elk Cr.** | 10 | 10” | 5 | 10” | 3 | 10” | 18 |
| **N. F. & Horseshoe** | 11 | 13” | 3 | 8” | 0 | | 14 |
| **Total** | 107 | | 81 | | 30 | | 218 |
| **Avg. Length** | | 10” | | 9” | | 9” | 10” |

## GIS Error Estimation

There is an inherent error associated with the using hand-held GPS units. Hand-held units have an accuracy of only about 100 meters which can be attributed to the selective availability introduced by Department of Defense, the geometry of satellite locations, canopy cover, and operator training. In 1999, crews used hand-held GPS units and the average error was slightly over the expected accuracy for the units (Table 12). The error for some streams was low with Swamp and Sheep averaging less than 60 meters. There was one location on the North Fork

Malheur River that had to be corrected almost a mile!

Table 12. The distance in meters locations were corrected so that all of the points would end up on a 1:100,000 GIS stream theme. Locations were moved in either a north-south or east-west direction.

| Stream | N | Avg. Distance | Range | %CV |
|---|---|---|---|---|
| **Swamp Cr.** | 89 | 56 | 0 - 955 | 206% |
| **Little Crane Cr.** | 57 | 193 | 0 – 760 | 110% |
| **Sheep Cr.** | 86 | 45 | 0 – 138 | 80% |
| **Elk Cr.** | 40 | 93 | 0 – 594 | 99% |
| **North Fork** | 28 | 310 | 0 – 1,108 | 93% |
| **Horseshoe Cr.** | 10 | 64 | 28 – 157 | 61% |
| **Deadhorse Cr.** | 4 | 35 | 0 - 84 | 109% |
| **Average** | | 114 | | |

Number of Bull trout per Redd

Bull trout were associated with 39 of 115 redd locations. In 51% of observations (20/39) only one bull trout was present, 38% (15/39) of observations a pair of bull trout, and in 10%(4/39) more than two bull trout were present. In one case, 4 bull trout were observed on or near one redd. On three of the four occasions with more than 2 bull trout per redd one or more individual fish were over 12 inches in length. This information is an initial step in trying to determine how many redds a female digs, how many males are associated, and perhaps help estimate spawning population size by using redd counts

Redd construction time

Because of an equipment failure the stream section on upper Little Crane was walked three times in three days. Between the first and second surveys two new redds were observed. Between the second and third surveys three new redds were observed. This would indicate redd construction can take about one day.

Egg Incubation

Four thermographs are deployed in fresh redds to try and learn more about time emergence.

Middle Fork Malheur River

The stream sections of Lake, Meadow Fork, and Snowshoe creeks surveyed in 1998 were surveyed again in 1999. New stream sections on Summit, Bosonberg, and lower Big creeks were surveyed this year.

Specific stream sections to be walked were determined by ease of access, 1993-94 population survey results, and experience gained from the North Fork basin. Stream sections probably will be adjusted over the next few years.

Snowshoe Creek

Snowshoe Creek was walked 3 times. It was walked from its mouth upstream 1.7 miles (Figure 5). No redds and no bull trout were observed during the September 1st survey. Eleven redds was observed during the September 15th survey. Fourteen redds were observed on the September 29th survey (Table 13). No bull trout were identified on any of the surveys. Many brook trout were observed during the later two surveys.

Table 13. Redds observed in Snowshoe Creek (1998-99).

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 10 | 1.7 | 5.9 |
| 1999 | 25 | 1.7 | 14.7 |

Meadow Fork Big Creek

Meadow Fork Big Creek was surveyed three times. The stream section walked was the same as the section walked in 1998 (Figure 6). Four redds and 25 bull trout were observed during the September 1st survey. Thirteen redds and 13 bull trout were observed during the September 15th survey. Eight redds and 2 bull trout were observed on the September 29th survey (Table 14).

Table 14. Redds observed in Meadow Fork Big Creek (1998-99).

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 39 | 3.3 | 11.8 |
| 1999 | 25 | 3.3 | 7.6 |

Lake Creek

Lake Creek was surveyed three times this year.. This year it was walked from the 1648 road upstream 4.3 miles (Figure 7). One redd was observed during the September 1st survey. Three redds and six bull trout were observed during the September 15th survey (Table 15). Seventeen redds and no bull trout were observed during the September 29th survey.

Table 15. Redds observed in Lake Creek (1998-99).

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 34 | 2.1 | 16.2 |
| 1999 | 21 | 4.3 | 4.9 |

Summit Creek

A section of Summit Creek was walked three times for the first time this year. It began at the first fence line below the 1660-598 road and ended 2.3 miles upstream of the 1665 road (Figure 8). No redds or bull trout were observed during the first survey on September 2nd. Three redds were observed during the second survey on September 16th. Fifteen redds were observed on the third survey on September 30th (Table 16).

Table 16. Redds observed in Summit Creek in1999.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1999 | 18 | 2.3 | 7.8 |

Big Creek

Two new sections of Big Creek were walked this year. The first starting at the 16 road and ending at the 1648 road, and the second starting at the 1648 road and ending at the mouth of Snowshoe Creek (Figure 9). The first section was walked once on September 16th. Four redds all with brook trout pairs on them were observed. The second section was walked three times, with one bull trout was observed during the September 16th survey and 4 redds observed during the September 30th survey (Table 17).

Table 17. Redds observed in Big Creek in 1999.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 0 | 2.3 | 0.0 |
| 1999 | 8 | 4.6 | 1.7 |

Bosonberg Creek

Several stream sections of Bosonberg Creek were surveyed twice in 1999 beginning at the 1648 road and ending upstream where the old railroad grade crossed the stream (Figure 9). The total distance walked was about 0.9 miles. No redds or bull trout were observed during any of the surveys.

Livestock Observations

Summit Creek, during the September 16th survey, was the only stream section where livestock were observed. The stubble height of herbaceous vegetation was estimated to be about 2 inches near the stream channel and about 4 inches away from the channel.

Bull Trout Observations

As in the North Fork Malheur Watershed, all crews counted and located most of the positively identified bull trout during the redd counts (Table 18). In the Middle Fork Watershed, positively identifying bull trout was difficult because of the presence of brook trout and brook-bull trout hybrids. There appeared to be a decrease in the number of fish observed.

Table 18. Number and average length of bull trout observed during the three spawning surveys on North Fork Malheur River streams in 1999.

| | **Sep. 1st Survey** | | **Sep. 15th Survey** | | **Sep. 29th Survey** | | |
|---|---|---|---|---|---|---|---|
| **Stream** | **N** | **Avg. Length** | **N** | **Avg. Length** | **N** | **Avg. Length** | **Total** |
| **Big Cr.** | 0 | | 1 | 13” | 0 | | **1** |
| **Meadow Fork** | 25 | 8” | 13 | 11” | 2 | 9” | **40** |
| **Snowshoe Cr.** | 0 | | 0 | | 0 | | **0** |
| **Lake Cr.** | 0 | | 6 | 8” | 0 | | **6** |
| **Summit Cr.** | 0 | | 0 | | 0 | | **0** |
| **Bosonberg Cr.** | 0 | | 0 | | | | **0** |
| **Total** | **25** | | **20** | | **2** | | **47** |
| **Avg. Length** | | **8”** | | **10”** | | **9”** | |

GIS Error Estimation

The average error was slightly higher than the expected error for the units (Table 19). The error for some of the streams was low with Meadow Fork, Snowshoe, and Summit creek averaging less than 70 meters, but one site on Lake Creek required a correction of almost 3 miles!

Table 19. The distance (m) locations were moved so that all of the points would end up on a 1:100,000 GIS stream theme. Locations were moved in either a north-south or east-west direction.

| Stream | N | Average | Range | %CV |
|---|---|---|---|---|
| **Meadow Fork** | 83 | 67 | 0 - 592 | 150% |
| **Snowshoe Cr.** | 33 | 53 | 0 - 289 | 117% |
| **Big Cr.** | 17 | 163 | 44 - 1203 | 166% |
| **Lake Cr.** | 37 | 315 | 0 - 4540 | 236% |
| **Summit Cr.** | 24 | 47 | 0 - 39 | 82% |
| **Bosonberg Cr.** | 6 | 29 | 0 - 91 | 128% |
| **Average** | | 112 | | |

## Discussion

Data collected since 1992 in the North Fork Malheur watershed indicates that spawning begins in late August, peaks in September (Figure 10). Redds have been observed as late as November 2. Spawning may vary from year to year depending upon weather and water conditions. The number of larger adults observed in August indicates that larger individuals may spawn earlier than smaller fish.

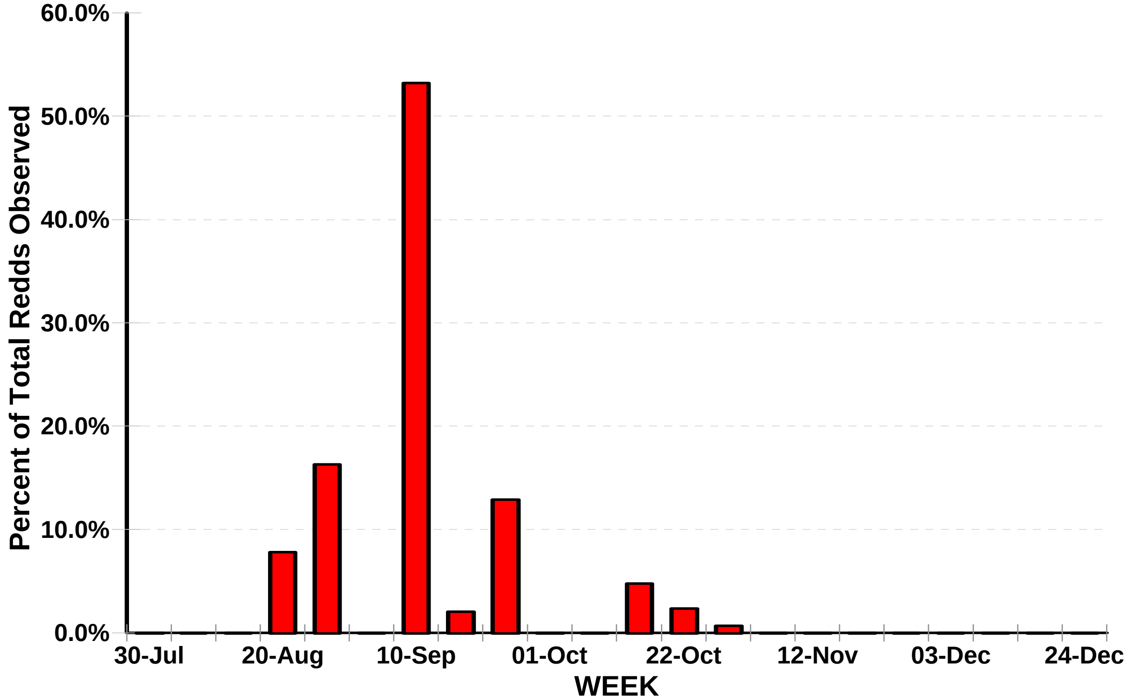



Figure 13. Bull trout spawning summarized by week for the North Fork Malheur River from 1992 to 1999.

In the North Fork Malheur watershed, most of the observed redds were located in its tributaries (Figure 11). Swamp and Little Crane creeks had most of the redds, but Sheep Creek continues to gain in importance as a spawning site. Most spawning occurs in areas with significant ground water influence.

The number of redds observed in the North Fork watershed increased again this year, but still is low for the number of miles surveyed (Table 20). The increase in redds counts after 1996 probably indicates an increase in the abundance of adult bull trout. Our surveys show that the spawning population of bull trout is still well below the 500 spawning adults needed to maintain genetic integrity.

To convert redd counts into fish numbers is a process with many assumptions. If one assumes that no mistakes were made in identifying redds and that one male and one female constructed one redd, then the number of spawning adults in the North Fork Malheur watershed is 230. However, as data collected this year indicates, at least 10 per cent of the time the number of bull trout associated with a redd may exceed two. This makes the multiplier 2.1 that would increase the number of bull trout to 242. Other data collected this year indicates that spawning pairs or groups may construct more than one redd. Which would lower the two estimates mentioned above.

Table 20. Bull trout redd counts in the North Fork Malheur River watershed in 1992-99.

| YEAR | REDDS | MILES[a] | REDDS/MILE | POPULATION ESTIMATE (redds x 2.1) |
|---|---|---|---|---|
| 1992 | 2[b] | 9.2 | 0.2 | |
| 1993 | 8 | 28.9 | 0.3 | |
| 1994 | 13 | 24.1 | 0.5 | |
| 1995 | 9 | 24.0 | 0.4 | |
| 1996 | 38 | 22.3 | 1.7 | 80 |
| 1997 | 64 | 17.6 | 3.6 | 134 |
| 1998 | 74 | 22.6 | 3.3 | 115 |
| 1999 | 115 | 22.3 | 5.2 | 242 |

[a] – Miles surveyed were changed for the years 1992 to 1998. New mileage better reflects actual mileage walked.

[b] - Does not includes 14 questionable redds observed by volunteers listed in earlier reports.

In the Middle Fork Malheur watershed, most of the redds and bull trout occurred in Meadow Fork, Snowshoe, and Big creeks (Figure 12). Meadow Fork and Snowshoe Creek contained most of the redds.  At present, there is no way to separate bull, brook, and bull/brook hybrid redds.

Determining the timing and number of bull trout spawning in the Middle Fork Malheur watershed streams is much more difficult because of the presence of brook trout.  We know from the North Fork Malheur watershed that bull trout spawning peaks during the week of September $10^{th}$ through $16^{th}$.  In the Middle Fork, 40 percent of redds were counted prior to the September $15^{th}$.  These redds were in streams where most 64% of the bull trout were also observed.  These redds were assumed to be bull trout redds, but brook trout were also present.  Meadow Fork from the trailhead (RM 2.0) to the falls (RM 3.3) contained the most redds associated with bull trout sightings.

Determining the number of spawning bull trout in this watershed is problematical because of the presence of brook trout and bull/brook hybrids (Table 21).  Better knowledge of brook trout and bull/brook hybrid spawning needed to see how much temporal and spatial over lap between these two species might occur.

Table 21.  Redd counts in the Middle Fork Malheur River watershed in 1998-99.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 82 | 9.4 | 8.7 |
| 1999 | 97 | 17.1 | 5.7 |

Appendix I

North Fork Malheur Stream Sections

Continue to walk all stream sections currently being walked.  Consideration might be given to including the lower mile or so of Deadhorse Creek.  Water Temperatures appear to be within the bull trout preferences although the gradient may be a little high and the substrate a little large.

Middle Fork Malheur stream Sections

Continue to walk Lake Creek (from 1648 road upstream about 4.3 miles), Meadow Fork (from mouth upstream to falls), Snowshoe Creek (mouth upstream to Wilderness Boundary), and Big Creek (from 1648 road upstream to Snowshoe Creek), and Summit Creek (from private property line upstream about 2.3 miles).  Big Creek (from the 16 road upstream to the 1648 road) should be walked early and late to complete a cycle (Three passes).  Bosonberg creek upstream of 1648 road probably does not need to be walked in the future.  The section of Bosonberg Creek downstream of the 16 road would be good section to walk if permission could be obtained. Lower Summit Creek downstream of the private land in the prairie should be walked early, middle and late to see where spawning is occurring. Crooked Creek should be walked similar to Lower Summit Creek just to document use.

Appendix II. Figures

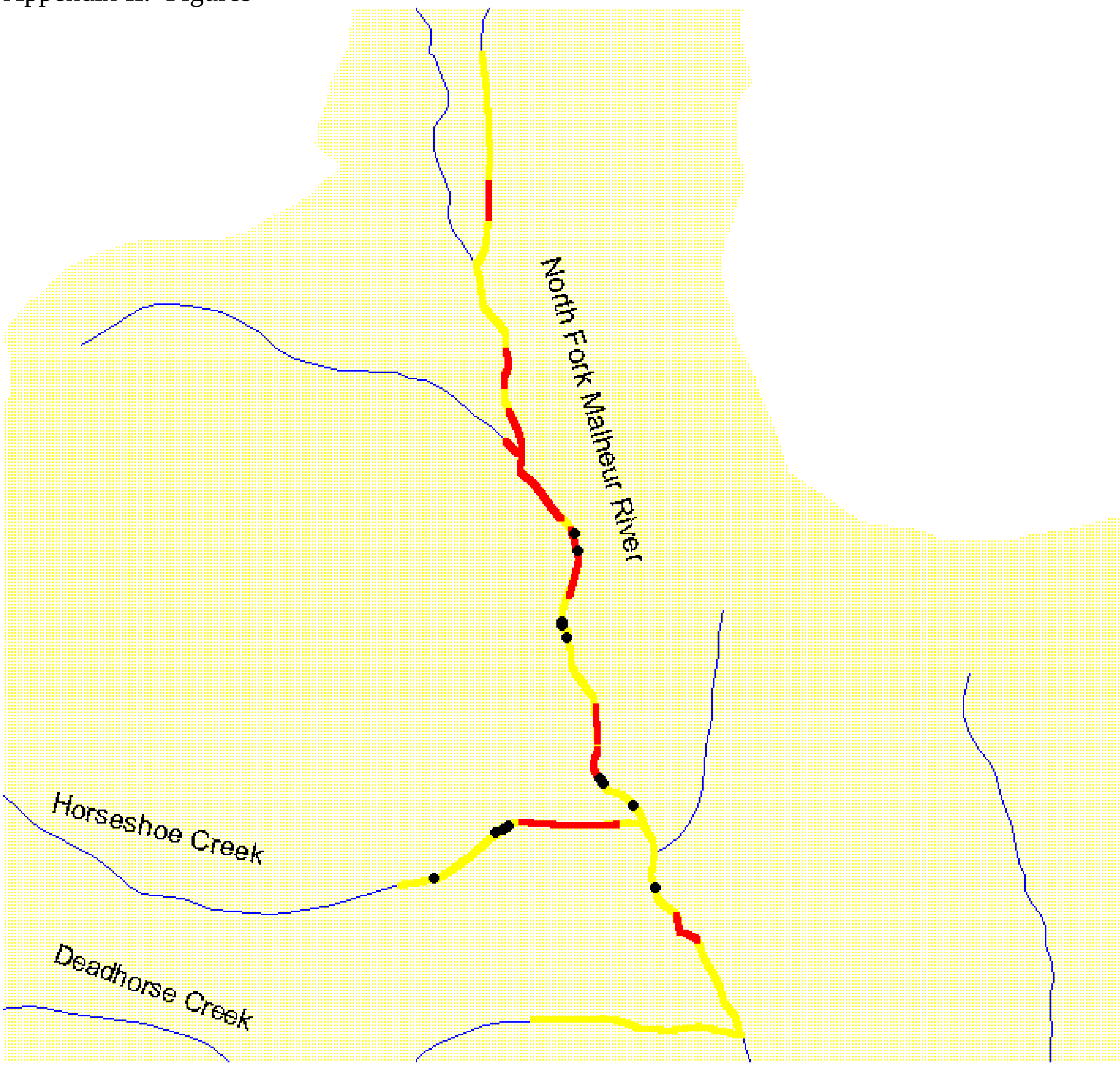



Figure 1. Location of redds in the upper North Fork Malheur River and Horseshoe Creek from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

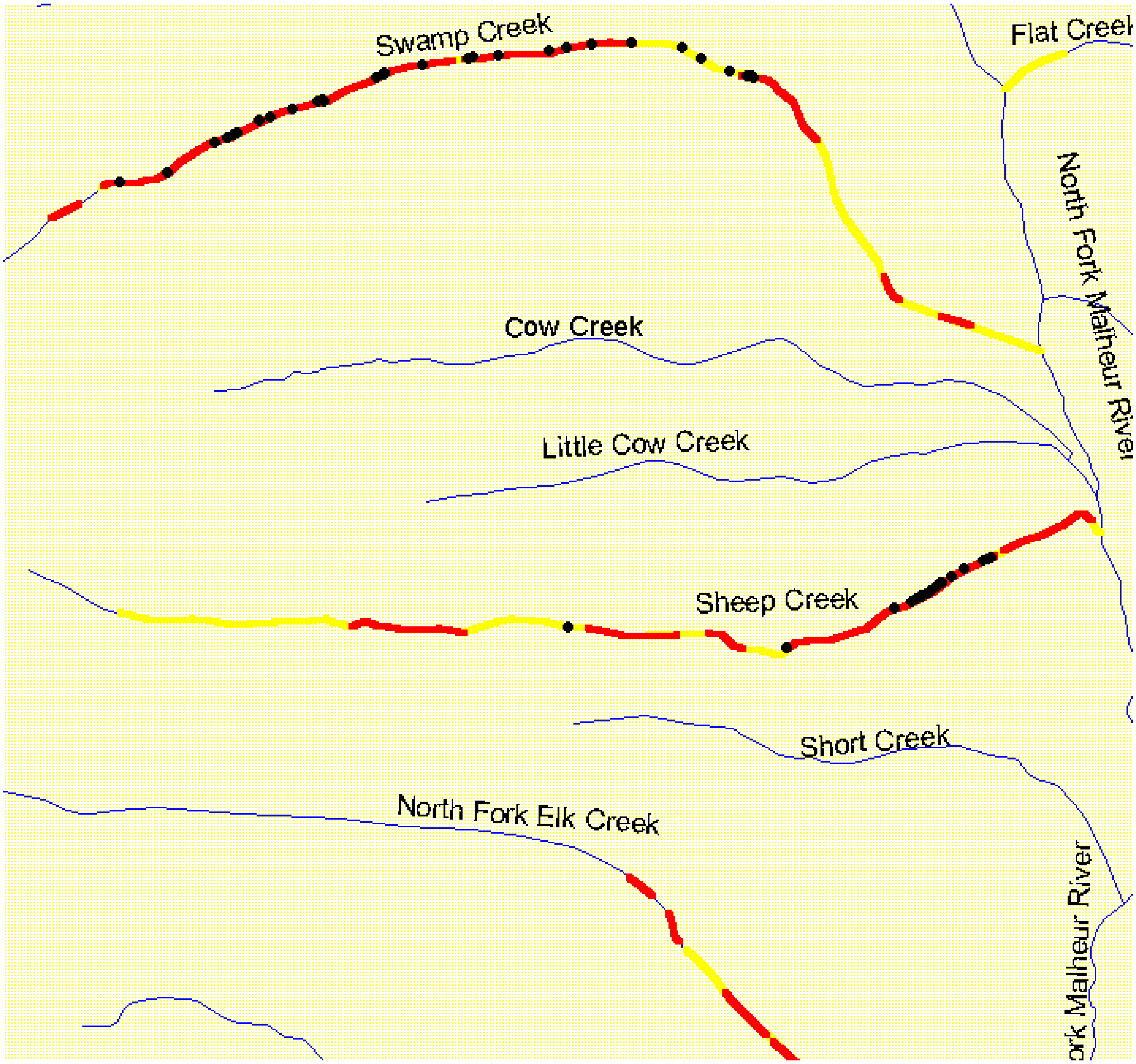


Figure 2. Location of redds in Swamp and Sheep creeks from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

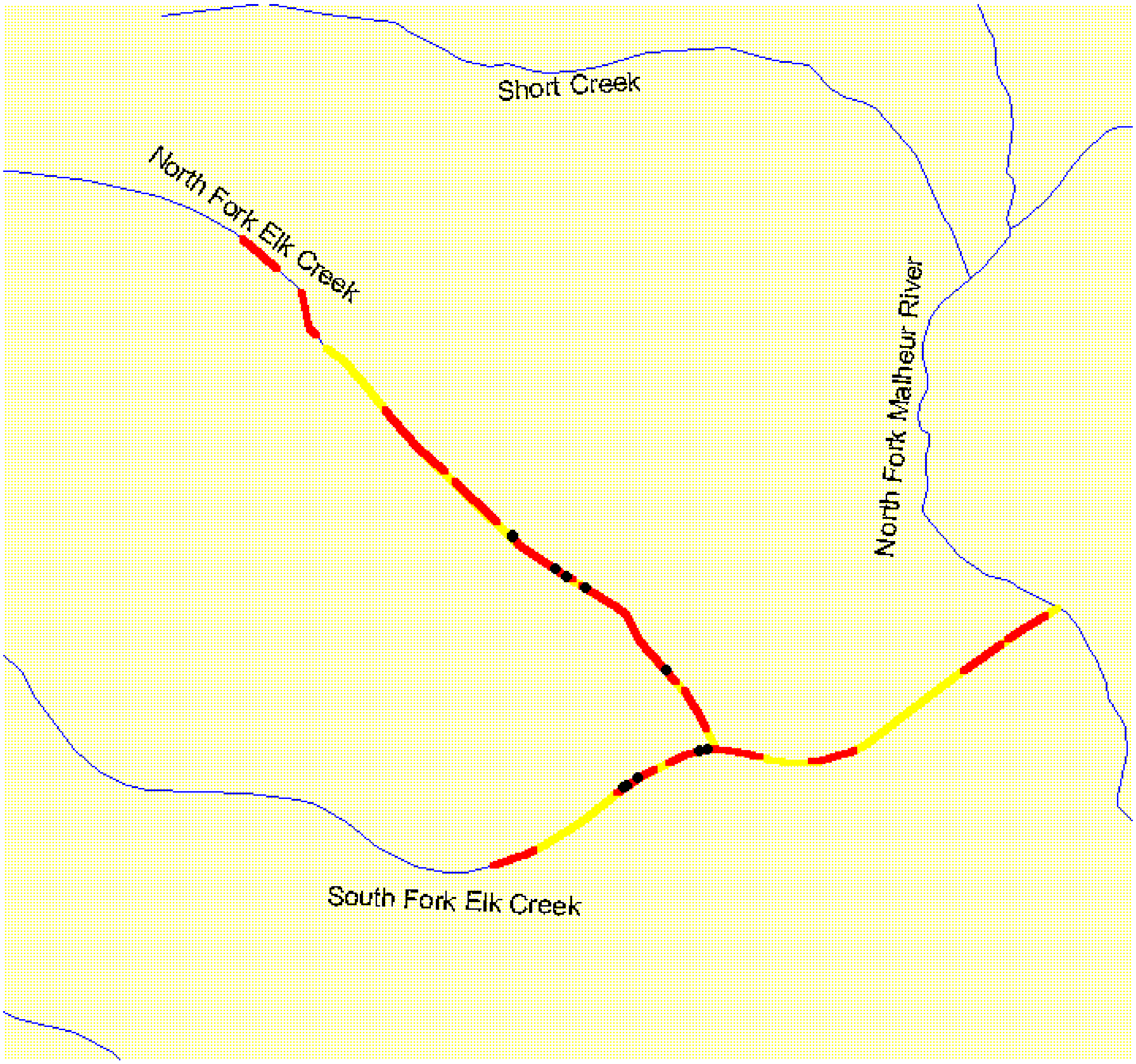



Figure 3. Location of redds in the Elk Creek from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

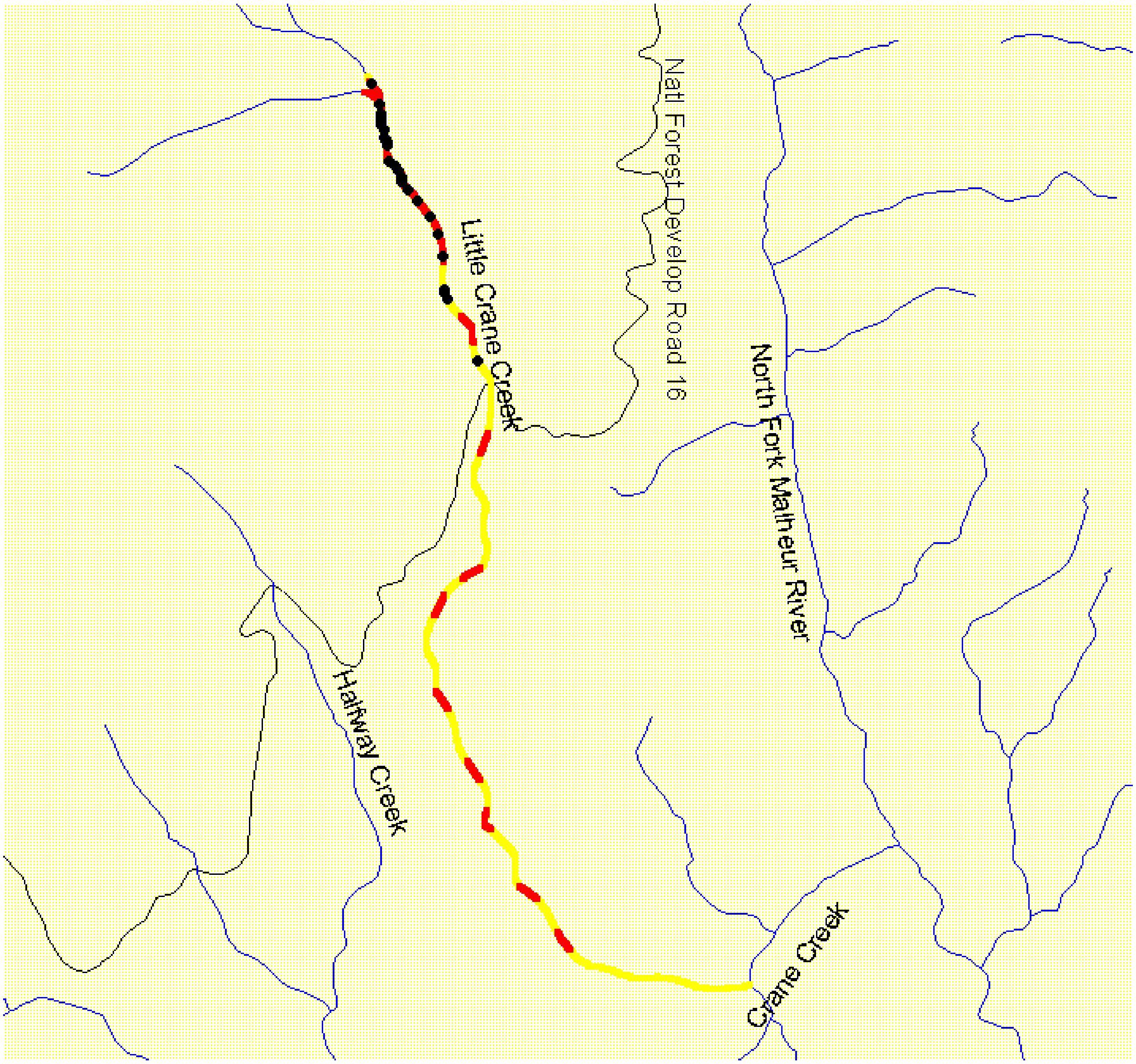



Figure 4. Location of redds in the Little Crane Creek from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

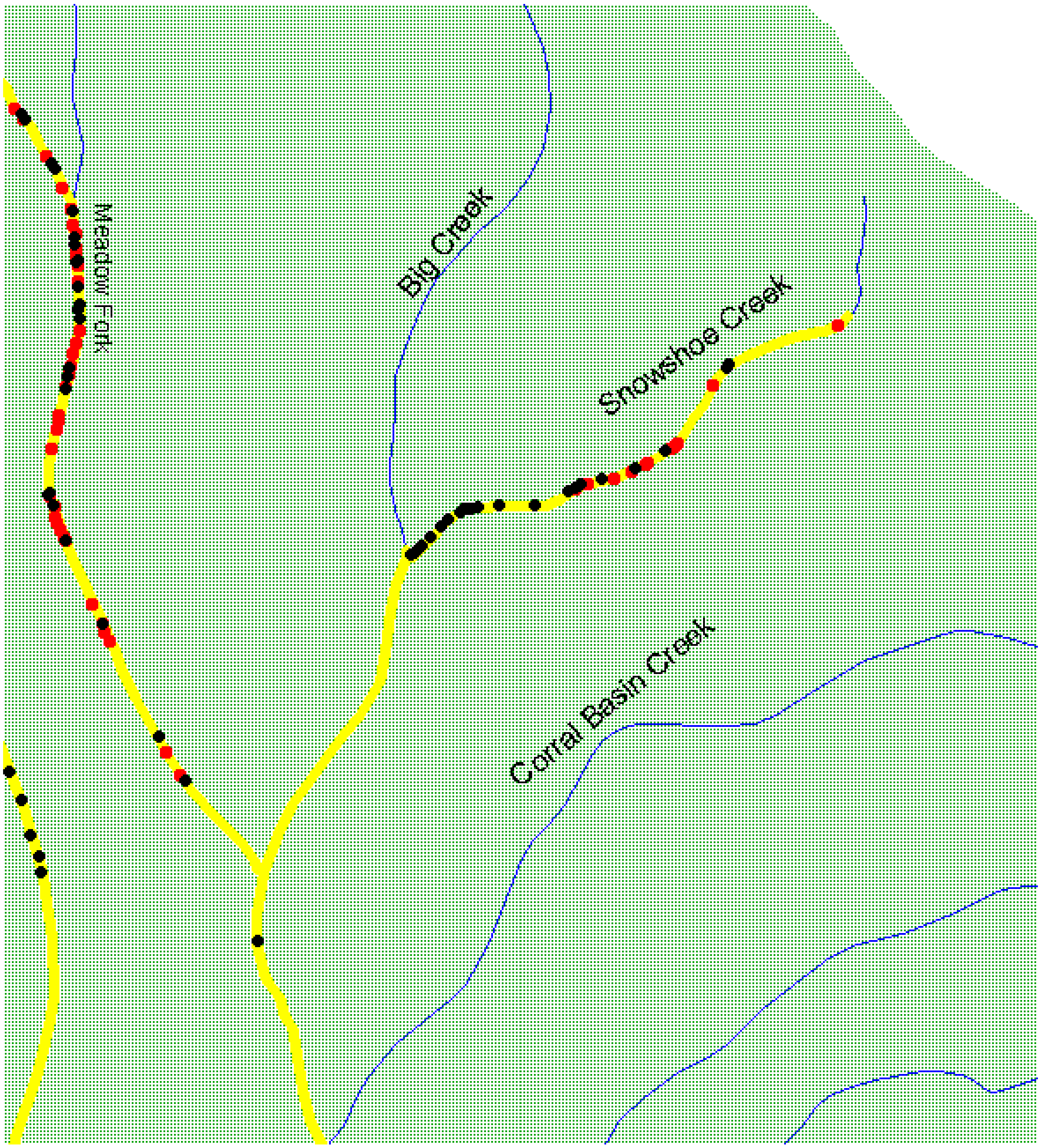



Figure 5. Location of redds in Snowshoe Creek from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

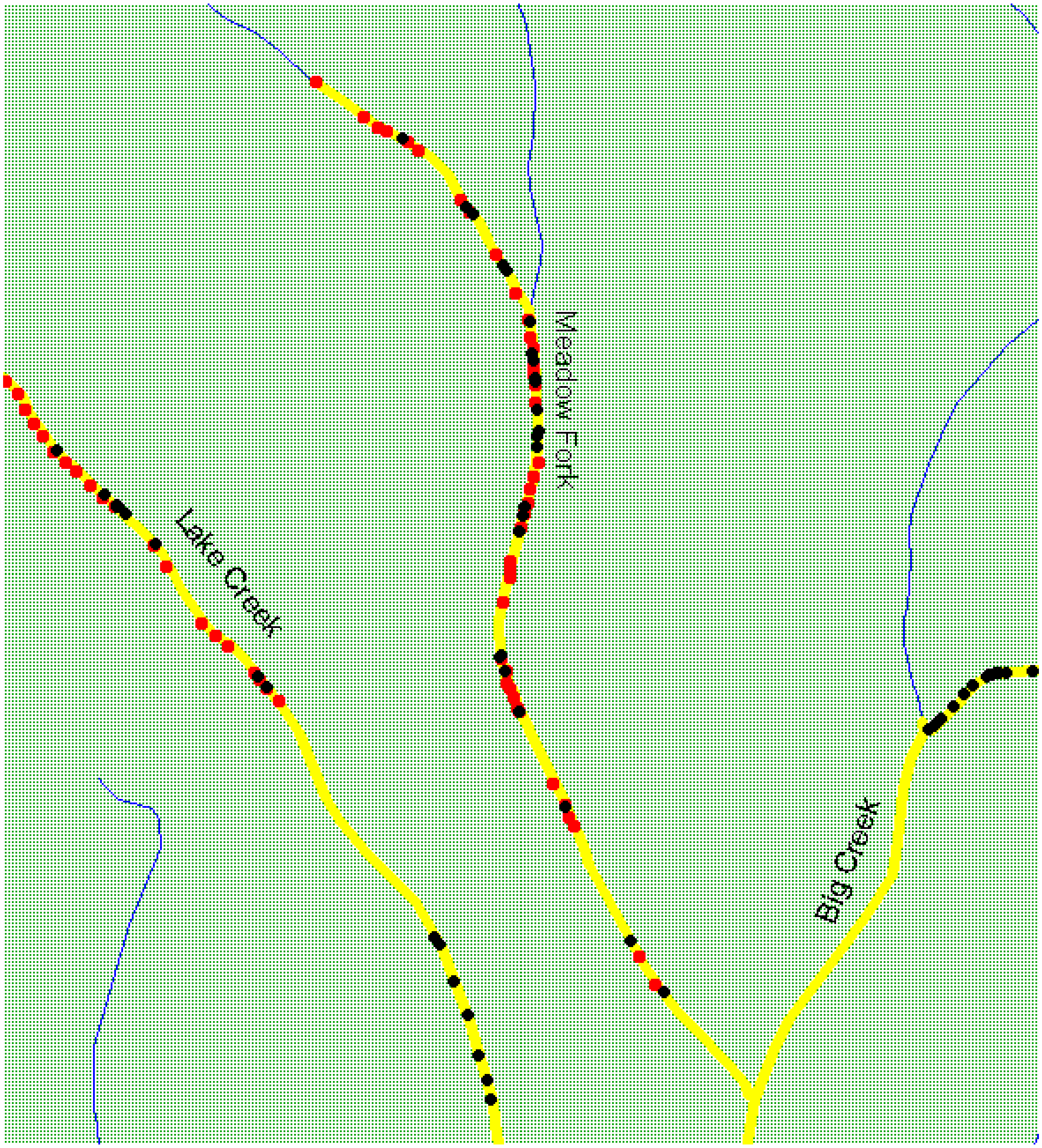



Figure 6. Location of redds in Meadow Fork from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

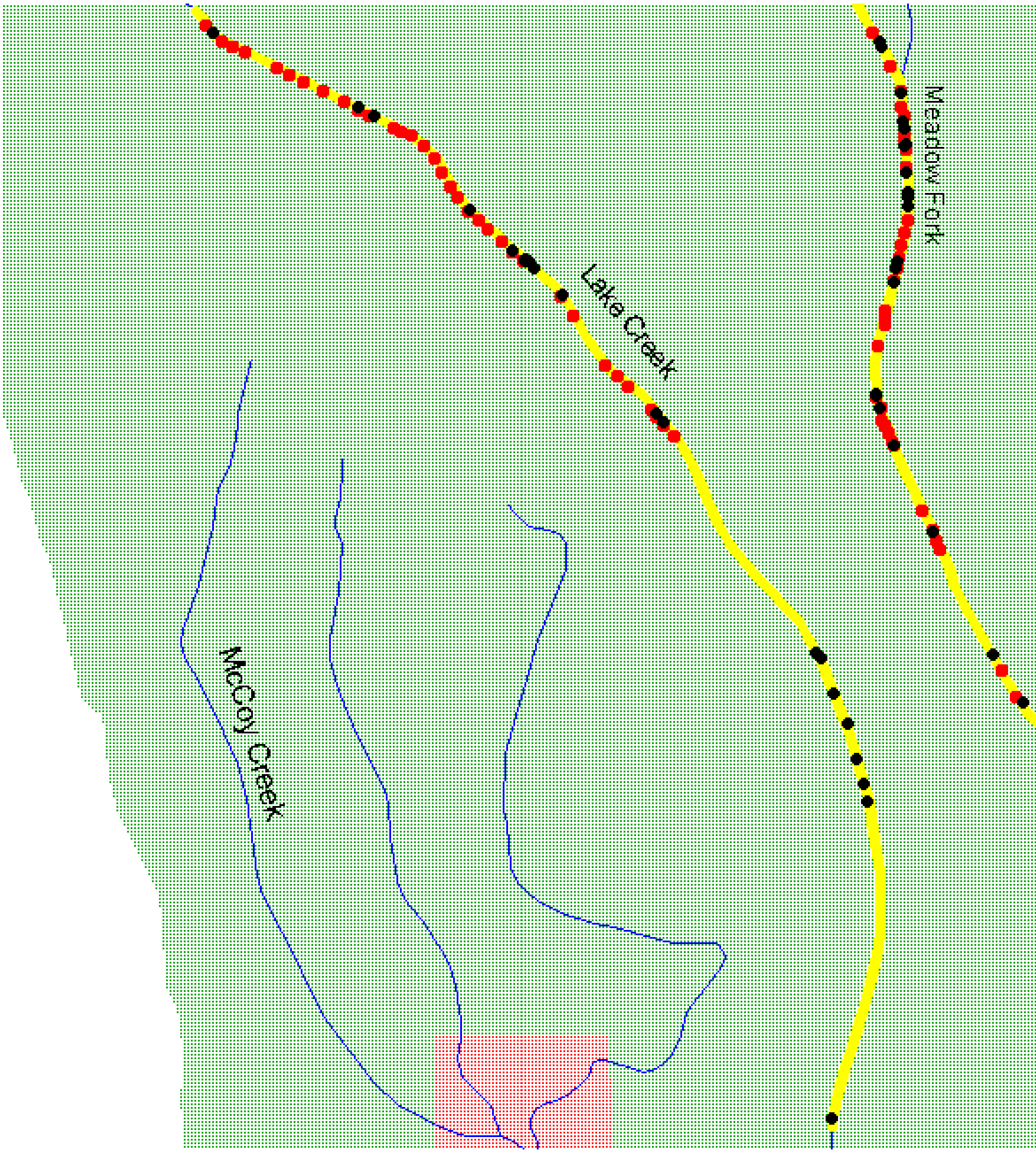



Figure 7. Location of redds in Lake Creek from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

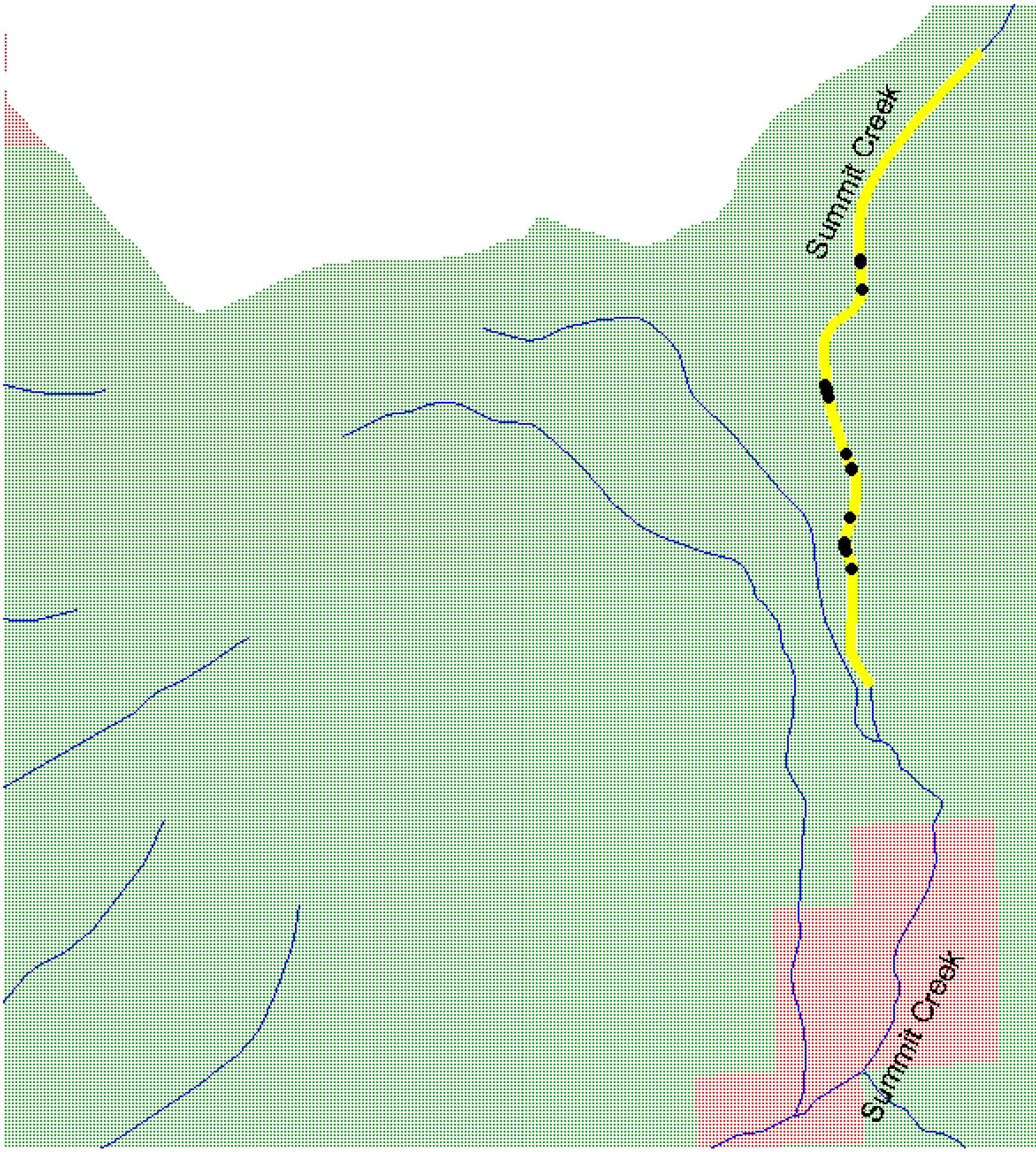



Figure 8. Location of redds in Summit Creek from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

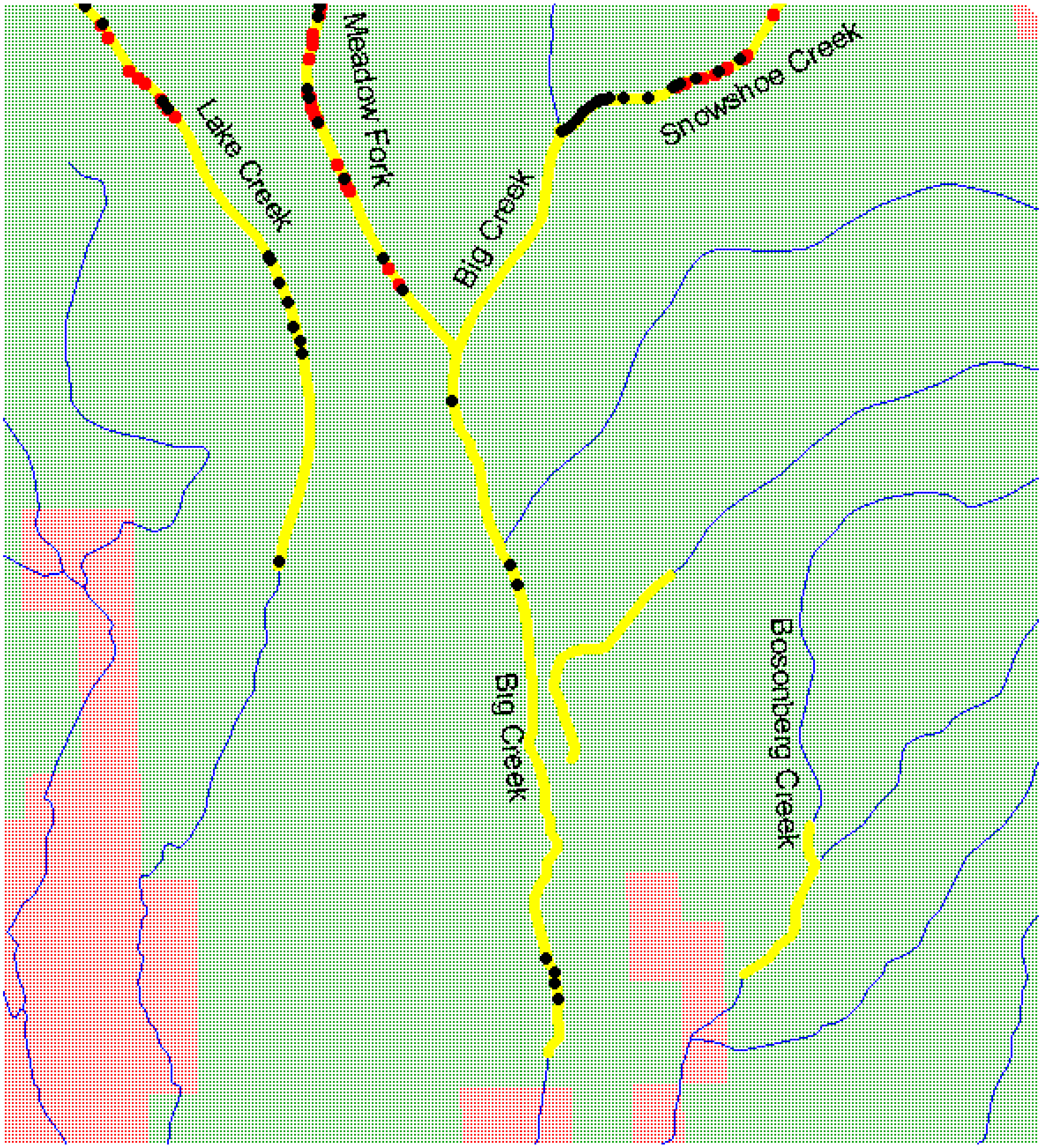



Figure 9. Location of redds in Big and Bosonberg creeks from 1999 spawning surveys (black dots). Yellow represents the stream segment walked. Red represents the location redds were observed from 1992 through 1998. Blue line is the stream.

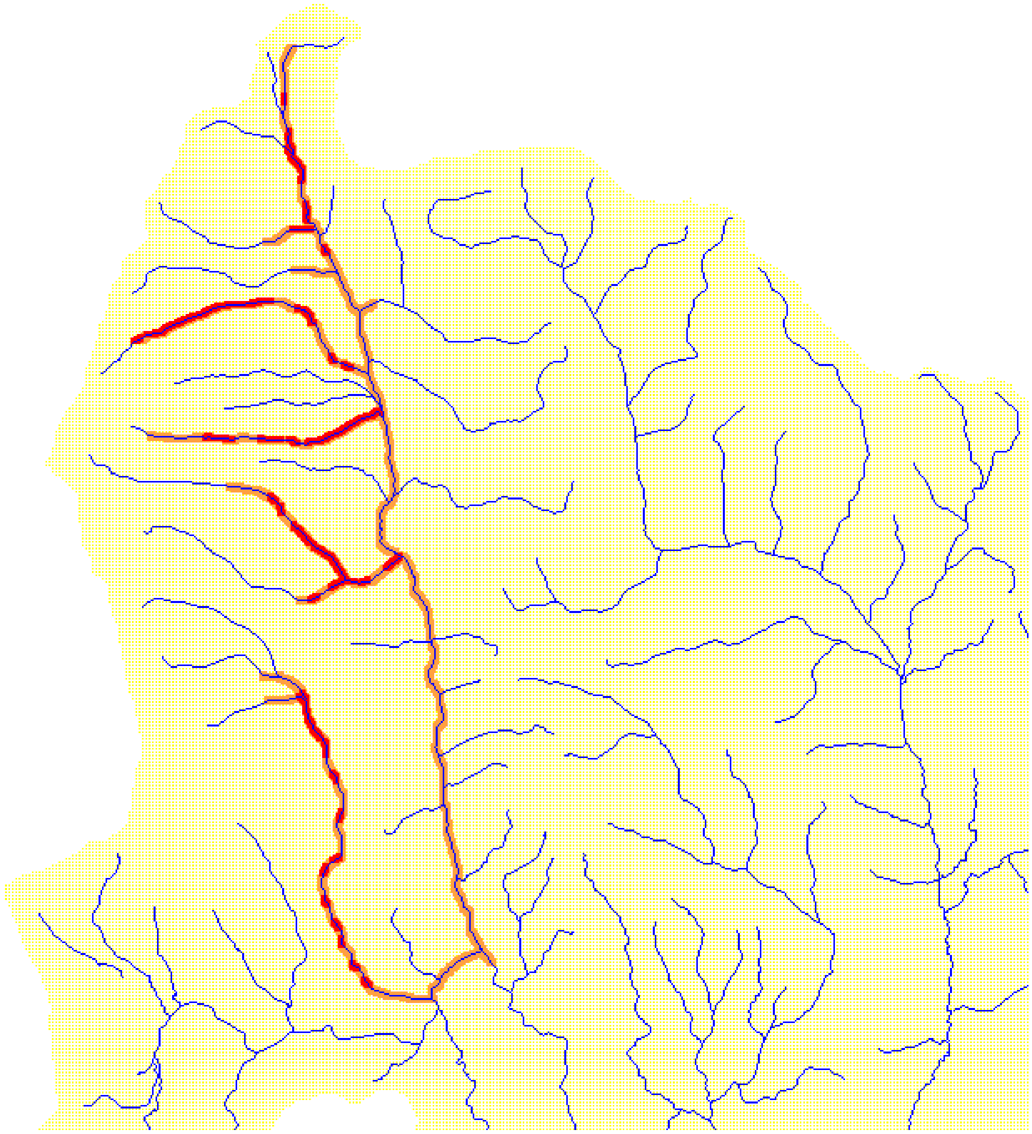


Figure 11. Core Spawning areas in the North Fork Malheur River Watershed from 1992 to 1998. Red represents redd locations ±100 meters. Orange represents stream sections walked from 1992 to 1999.

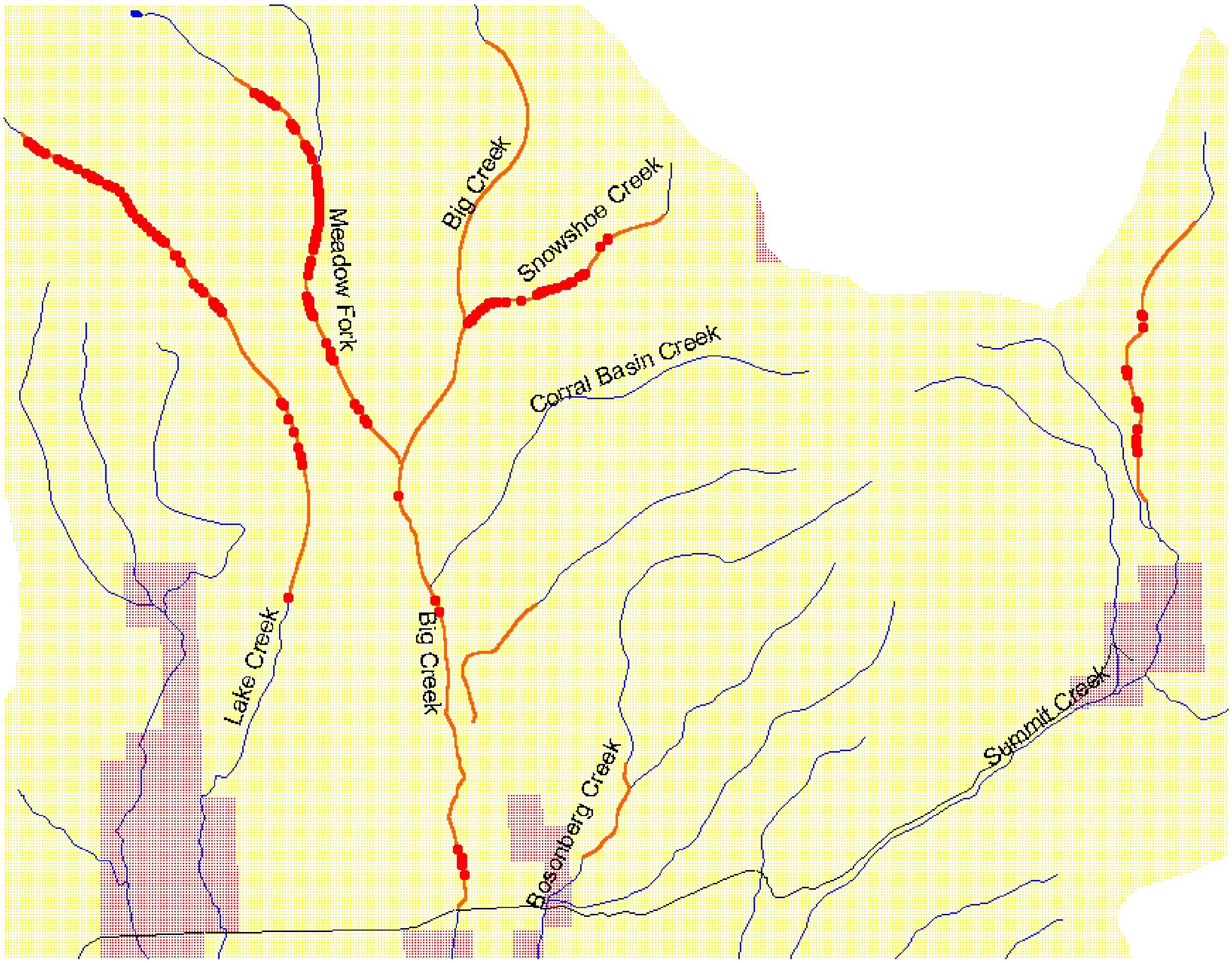


Figure 12. Core spawning areas in the Middle Fork Malheur River Watershed from 1992 to 1998. Red represents redd locations. Orange represents stream sections walked from 1998 to 1999.

**SPECIAL REPORT**
**SOUTHEAST FISHERIES DISTRICT**
**RAY PERKINS**
**December, 1999**

# MALHEUR RIVER BULL TROUT POPULATION STATUS 1999

This report summarizes activities conducted in the Malheur River basin associated with bull trout in 1999. Activities include; water temperature monitoring, and bull trout spawning surveys. The spawning survey section will include information from previous years.

## Water Temperature Monitoring

### Objectives

ODFW deploys thermographs to record baseline water temperature data within the distribution of bull trout in the Malheur River Basin. Thermographs are deployed to take advantage of discharge measurement and instream water right segments.

### Methods

During the late fall, winter and early spring water temperatures are usually well within the tolerance of most fish present in the Malheur River Basin. During late spring, summer and early fall water temperatures can exceed temperature tolerances of trout. This can occurs most often during the summer. Thermographs are usually deployed during the month of June to record water temperatures during the hot part of the summer (July 15 – August 15). They are left in through September to record water temperatures during bull trout spawning.

The highest water temperatures usually occur between mid-July and mid-August, but can occur as early as June or as late as September. To describe summer rearing water temperature thermographs are deployed to record data during the summer critical period (July 15 through August 15). The data collected each year is averaged over this period producing an annual average. The annual averages for each site are then averaged to produce a period of record average, or normal, for each specific site. This period of record average can be compared to annual averages to determine deviation from normal. The same procedure is used to produce annual averages and period of record average for the month of September for each site.

### Results

North Fork Malheur River

Twelve thermographs were deployed in the watershed by ODFW (Table 1 and 2). One thermograph near the 1370 Road Bridge was lost due to vandalism. Nine were deployed in streams by USFS. One was located in the North Fork at river mile 50. Two were located near the mouths of Crane and Sheep creeks. One in Little Crane Creek upstream of Forest Road 16 and a max-min thermometer in Elk Creek near its mouth. Four more thermographs were deployed into streams outside bull trout distribution, one in Little Malheur River near 16 road, one in Squaw Creek near boundary, two in Bear Creek. Four were deployed in the lower basin by Vale BLM of these three were located in the North Fork; one near the USGS discharge gage, one just upstream of Little Malheur River, and the third near Chukar Park 5 miles downstream of the Agency Valley Dam. The fourth one was located in the Little Malheur River just upstream of its mouth.

Table 1. Comparison of 1999 July 15 through August 15 average daily water temperature with the July 15 through August 15 average daily water temperature for the period of record at the twelve sites monitored in the North Fork Malheur River watershed in 1999.

| STREAM NAME | RM | 1999 Jul 15 – Aug 15 Average Daily Water Temp | Period of Record Jul 15 – Aug 15 Average Daily Water Temp | ±1 Std. Dev. | Δ°C | Period of Record |
|---|---|---|---|---|---|---|
| N. F. Malheur R. | 0 | 17.3°C | 18.0°C | ±1.5°C | -0.7°C | 1996, 1999 |
| N. F. Malheur R. | 18 | 15.2°C | | | | 1999 |
| N. F. Malheur R. | 44 | 14.5°C | 16.1°C | ±2.4°C | -1.6°C | 1994-1999 |
| N. F. Malheur R. | 47 | 13.6°C | 14.6°C | ±1.3°C | -1.0°C | 1996-1999 |
| N. F. Malheur R. | 52 | 11.4°C | 12.3°C | ±1.1°C | -0.9°C | 1996-1999 |
| N. F. Malheur R. | 55 | LOST | 10.2°C | ±0.8°C | | 1995-1998 |
| N. F. Malheur R. | 58 | 8.8°C | 9.4°C | ±0.7°C | -0.6°C | 1996-1999 |
| N. F. Malheur R. | 60 | 4.5°C | 4.6°C | ±0.1°C | -0.1°C | 1996-1999 |
| Swamp Cr. | 0 | 10.0°C | 10.7°C | ±1.0°C | -0.7°C | 1994-1999 |
| Swamp Cr. | 3 | 8.9°C | 9.4°C | ±0.9°C | -0.5°C | 1995-1999 |
| Horseshoe Cr. | 0 | 8.9°C | | | | 1999 |
| Deadhorse Cr. | 3 | 8.2°C | | | | 1999 |

Table 2. Comparison of 1999 September average daily water temperature and the September average daily water temperature for the period of record at the twelve sites monitored in the North Fork Malheur River watershed in 1999.

| STREAM NAME | RM | 1999 September Average Daily Water Temp | Period of Record September Average Daily Water Temp | ±1 Std. Dev. | Δ°C | Period of Record |
|---|---|---|---|---|---|---|
| N. F. Malheur R. | 0 | 16.3°C | 16.3°C | ±1.8°C | 0.0°C | 1996, 1999 |
| N. F. Malheur R. | 18 | 17.3°C | | | | 1999 |
| N. F. Malheur R. | 44 | 9.8°C | 10.3°C | ±0.2°C | -0.5°C | 1994-1999 |
| N. F. Malheur R. | 47 | 9.4°C | 10.3°C | ±2.2°C | -0.9°C | 1996-1999 |
| N. F. Malheur R. | 52 | 8.0°C | 8.8°C | ±1.9°C | -0.8°C | 1996-1999 |
| N. F. Malheur R. | 55 | LOST | | | | 1995-1998 |
| N. F. Malheur R. | 58 | 5.8°C | 7.1°C | ±1.5°C | -1.3°C | 1996-1999 |
| N. F. Malheur R. | 60 | 4.6°C | 4.7°C | ±0.1°C | -0.1°C | 1996-1999 |
| Swamp Cr. | 0 | 7.1°C | 8.0°C | ±1.5°C | -0.9°C | 1994-1999 |
| Swamp Cr. | 3 | 6.3°C | 7.1°C | ±1.7°C | -0.8°C | 1995-1999 |
| Horseshoe Cr. | 0 | 5.9°C | | | | 1999 |
| Deadhorse Cr. | 0 | 6.3°C | | | | 1999 |

Middle Fork Malheur River

Seventeen thermographs were deployed in the basin upstream of Hog Flat by ODFW (Table 3 and 4). Five were deployed in streams upstream of Malheur Ford by USFS staff. One was located in the Malheur River near Malheur Ford (River Mile 185). Four were located in tributaries; two in Summit Creek, one in Big Creek upstream of Snowshoe Creek, and one in Lake Creek near the Trailhead.

## Discussion

The July 15 to August 15 daily mean water temperature for eight monitoring sites in the North Fork Malheur River was 0.8°C cooler than the long-term average. The September daily mean water temperature for the same sites was 0.7°C cooler than the long-term average. The July 15 to August 15 daily mean water temperature for nine monitoring sites in Logan Valley streams was 0.8°C cooler than the long-term average. The September daily mean water temperature for the same sites was 0.8°C cooler than the long-term average.

The summer of 1999 had a cool beginning and warm conclusion. The July average air temperature as measured at the Malheur Co. Experiment Station was 1.2°C cooler than average. The August average air temperature was 0.6°C warmer than average. The September average air temperature was normal.

The cooler than normal air temperatures in July help to explain the cooler than average water temperatures experienced in both watersheds. The slightly above normal August air temperatures and average September air temperatures lead one to other explanations of cooler than average water temperatures. The larger than normal 1998-99 snow pack and higher than normal summer stream flows may help to explain the cooler water temperatures.

Table 3. Comparison of 1999 July 15 through August 15 average daily water temperature with the July 15 through August 15 average daily water temperature for the period of record at the twelve sites monitored in the Logan Valley streams in 1999. The red entry in Δ°C column indicates change greater than 1 standard deviation from the mean.

| STREAM NAME | RM | 1999 Jul 15 – Aug 15 Average Daily Water Temp | Period of Record Jul 15 – Aug 15 Average Daily Water Temp | ±1 Std. Dev. | Δ°C |
|---|---|---|---|---|---|
| Meadow Fork | 2.0 | 10.8°C | | | |
| Big Creek | 5.2 | 8.5°C | | | |
| Big Creek | 2.9 | 10.5°C | 10.8°C | ±1.1°C | -0.3°C |
| Big Creek | 0.1 | 13.1°C | 13.7°C | ±1.3°C | -0.6°C |
| Lake Creek | 6.2 | 9.7°C | 10.6°C | ±1.2°C | -0.9°C |
| McCoy Creek | 3.0 | 9.8°C | 10.6°C | ±1.1°C | -0.8°C |
| Lake Creek W | 3.4 | 12.9°C | 13.4°C | ±1.5°C | -0.5°C |
| Lake Creek E | 3.4 | 13.9°C | 15.4°C | ±1.9°C | -1.5°C |
| McCoy Creek | 1.0 | 16.9°C | 17.7°C | ±1.5°C | -0.8°C |
| Lake Creek | 2.5 | 15.1°C | | | |
| Summit Creek | 14.0 | 8.5°C | | | |
| Crooked Creek | 0.5 | 16.1°C | | | |
| MFMR@Hog Flat | 176 | 17.0°C | 18.5°C | ±1.8°C | -1.5°C |

Table 4. Comparison of 1999 September average daily water temperature with the September average daily water temperature for the period of record at the twelve sites monitored in the Logan Valley streams in 1999. The red entry in Δ°C column indicates change greater than 1 standard deviation from the mean.

| STREAM NAME | RM | 1999 September Average Daily Water Temp | Period of Record September Average Daily Water Temp | ±1 Std. Dev. | Δ°C |
|---|---|---|---|---|---|
| Meadow Fork | 2.0 | 5.9°C | | | |
| Big Creek | 5.2 | 6.2°C | | | |
| Big Creek | 2.9 | 10.5°C | 10.8°C | ±1.1°C | -0.3°C |
| Big Creek | 0.1 | 9.1°C | 9.7°C | ±1.9°C | -0.6°C |
| Lake Creek | 6.2 | 6.9°C | 8.0°C | ±1.8°C | -1.1°C |
| McCoy Creek | 3.0 | 7.7°C | 8.7°C | ±1.4°C | -1.0°C |
| Lake Creek W | 3.4 | 6.0°C | 8.5°C | ±2.9°C | -2.5°C |
| Lake Creek E | 3.4 | 10.4°C | 10.6°C | ±2.4°C | -0.2°C |
| McCoy Creek | 1.0 | 11.1°C | 12.2°C | ±1.5°C | -1.1°C |
| Lake Creek | 2.5 | 9.9°C | | | |
| Summit Creek | 14.0 | 6.2°C | | | |
| Crooked Creek | 0.5 | 10.5°C | | | |
| MFMR@Hog Flat | 176 | 11.4°C | 12.4°C | ±2.4°C | -1.0°C |

# Malheur River bull trout distribution and water/habitat quality

**Author: Lawrence Schwabe, Burns Paiute Fish and Wildlife Department, Burns, Oregon**

## Introduction

Efforts to identify habitat and water quality conditions have continued in 1999. Resident fish have suffered significant habitat loss and degradation due to land-use factors such as timber harvest, livestock production, and irrigation withdrawals. Bull trout *Salvelinus confluentus* have specific environmental requirements and complex life histories making them especially susceptible to human activities that alter their habitat (Howell and Buchanan 1992).

In 1993, Bowers *et. al.* noted from the surveys conducted in the Middle Fork Malheur Basin that bull trout were found only in the tributaries Lake Creek (RM 195) and Big Creek (RM 190). Ratliff and Howell, in 1992, listed habitat degradation as the primary cause for depletion of bull trout in this area. Recent observations of bull trout from anglers and agencies report bull trout in areas outside the current distribution in the Middle Fork Malheur basin. The Burns Paiute Tribe collected a bull trout out of Crooked Creek in 1998, about 2 miles upstream from the confluence with Lake Creek. But as a general rule, the capture of bull trout outside their current distribution area is uncommon in the Middle Fork Malheur basin.

1999 Research Objects:

4) Evaluate the habitat profile of critical and potential bull trout spawning and rearing tributaries.
5) Determine cold-water micro-refugia within the Malheur Basin.
6) Determine stream temperature trends.
7) Correlate North Fork Malheur River stream temperatures with migratory bull trout distribution.

The study area includes the Middle and North Fork Malheur basins above Warm Springs Reservoir and Beulah Reservoir respectively (map 1). Stream surveys were done in the upper Middle and North Fork Malheur basins (map 2) and temperature probes place in the North Fork Malheur River above Beulah Reservoir (map 3). Aerial photos of the North Fork Malheur River were taken using Forward Looking Infra-Red (FLIR) photography from Beulah Reservoir up to its spring source.

## Methods

*Habitat Surveys*

In 1998, stream surveys were conducted on Wolf Creek and East Fork Wolf Creek using ODFW 1998 stream inventory protocol (ODFW, 1998). In 1997, stream surveys were conducted on Buttermilk and Summit Creek using ODFW 1997 stream inventory protocol. ODFW did the analysis of these streams and returned a written report to the Tribe in 1999.

Dambacher and Jones (1997) found seven variables to be important descriptors of juvenile bull trout (<170 mm fork length) habitat: (1) High amounts of shade; (2) undercut banks; (3) large woody debris volume; (4) large woody debris pieces; (5) gravel in riffles; (6) low amounts of bank erosion; and (7) fines in riffles. The benchmarks of habitat quality developed by Dambacher and Jones will be used to describe the quality of juvenile bull trout habitat in the Middle Fork Malheur River subbasin.

*Forward Looking Infrared (FLIR) Videography*

Thermal infrared images collected on the N.F. Malheur River Survey are used to develop broad scale temperature patterns in the basin. The images were collected using a helicopter mounted thermal infrared (TIR) radiometer (also know as FLIR). The radiometer was co-located with a day TV video camera in a gyro-stabilized gimbal mount and images were collected by flying longitudinally over the center of the stream channel. The TIR images were tagged with position information from a global positioning system (GPS) and recorded directly to an on-board computer. The imagery from the Day TV camera was also tagged with GPS positions and recorded to a videocassette recorder on the helicopter. The survey was conducted between 2:27 pm and 3:00 pm on 6 August 1998.

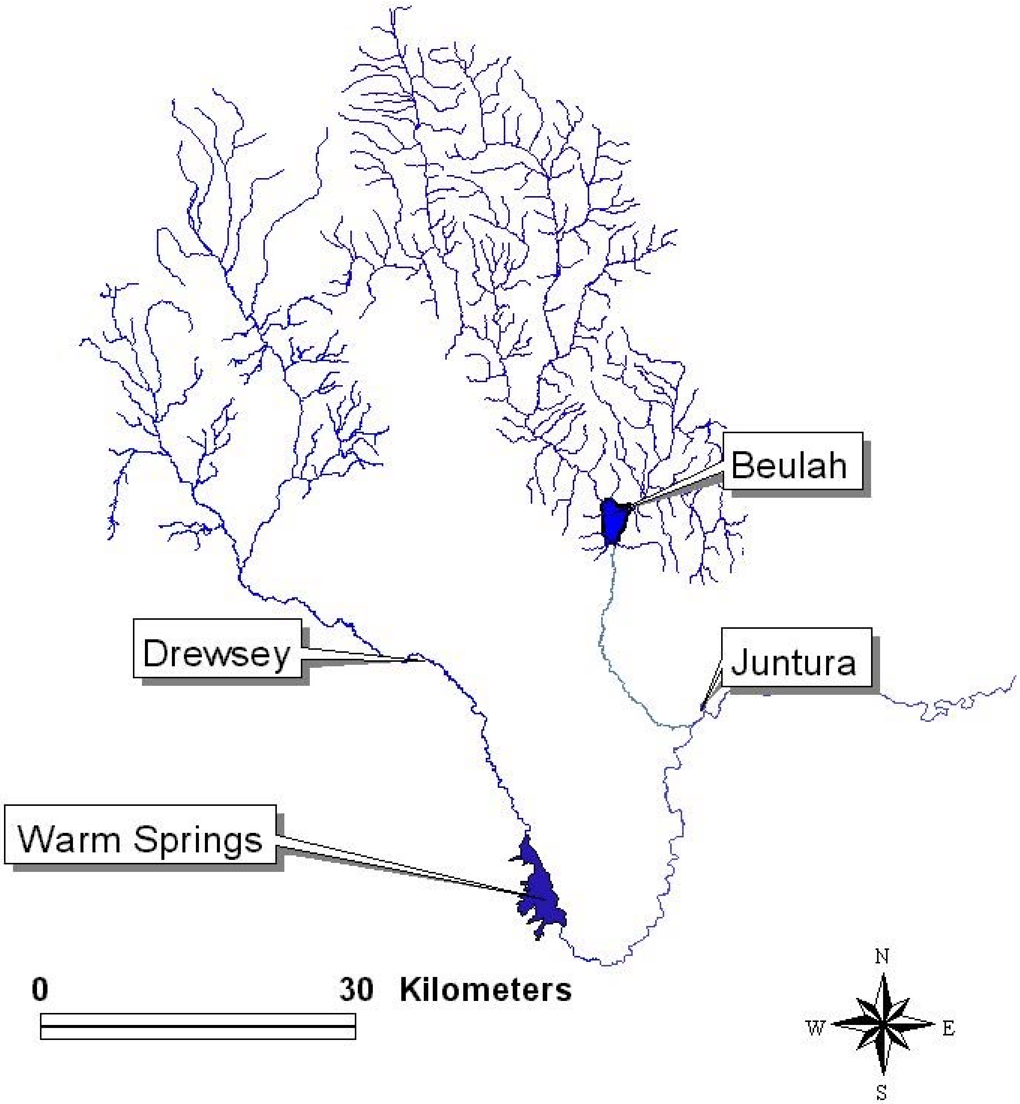
The radiometer measures the thermal infrared energy emitted from the water's surface as well as other objects in the scene. The measured energy is converted to temperature by knowing the conditions under which the images were collected and the emissivity of water. As a result, each pixel in the image represents the radiant temperature at that location. To verify the accuracy of the radiant temperatures, three (*Onset Stowaway*) temperature loggers were placed in the river during the survey. The first was located just upstream of the Rd. 1370 bridge, the second was placed just upstream of the Rd. 16 bridge, and the last was placed just upstream of the Bridge leading to the N.F. campground.

*Correlation Between Bull Trout Migration and Stream Temperatures*

The Burns Paiute Tribe collected raw stream temperature data from the Oregon Department of Fish and Wildlife, the Bureau of Reclamation, the Bureau of Land Management, and US Forest Service. Data on six stream temperature sites located on the North Fork Malheur River are all located above Beulah Reservoir. The distribution of adult migrating bull trout through our telemetry effort will be correlated with these six stream temperature sites. Temperatures that exceed the seven-day maximum running average of 17.8$^{o}$C will be considered water quality limited for bull trout (Buchanan and Gregory, 1997). Sites are as follows:

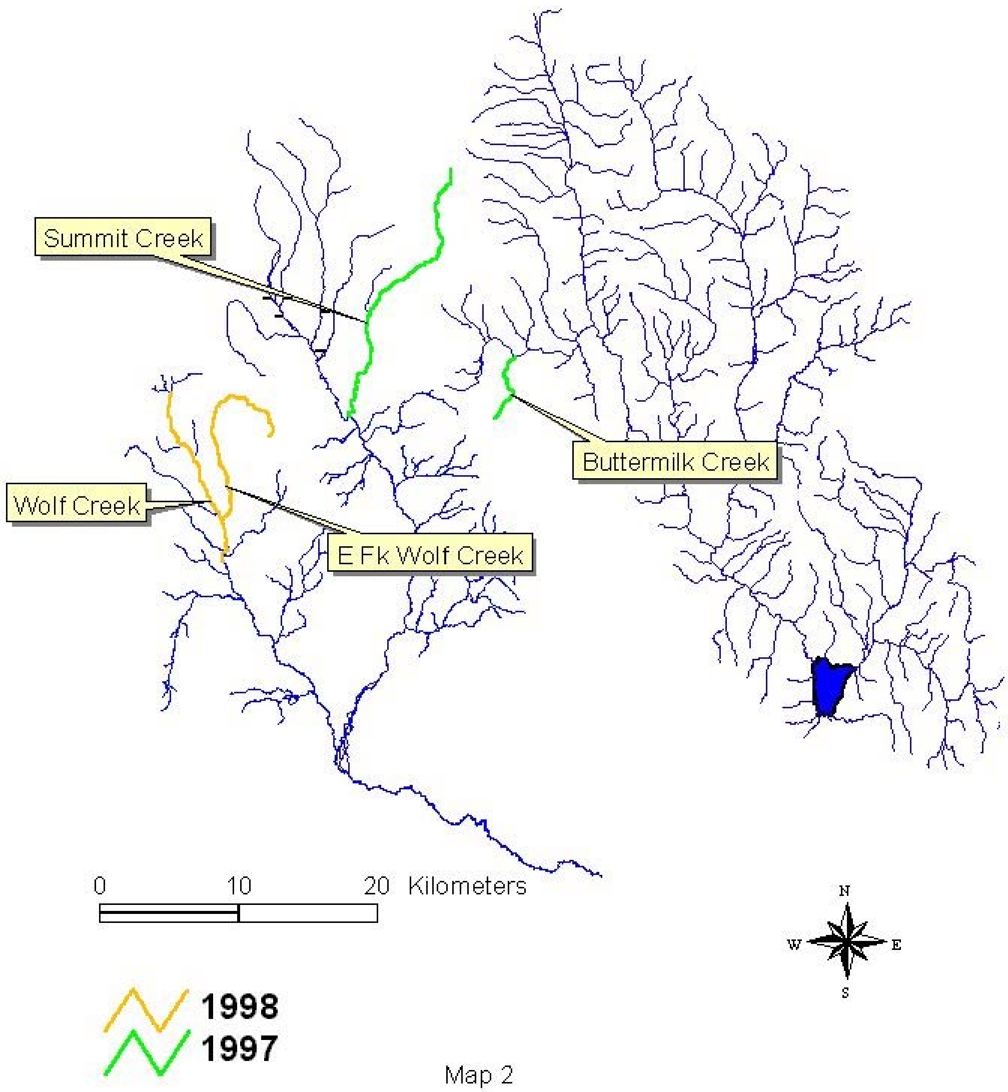
1.) River kilometer 34 – BOR temp site
2.) River kilometer 56 – BLM temp site
3.) River kilometer 69 – USFS temp site
4.) River kilometer 75 – ODFW temp site
5.) River kilometer 81 – USFS temp site
6.) River kilometer 83 – ODFW temp site

# Study Area



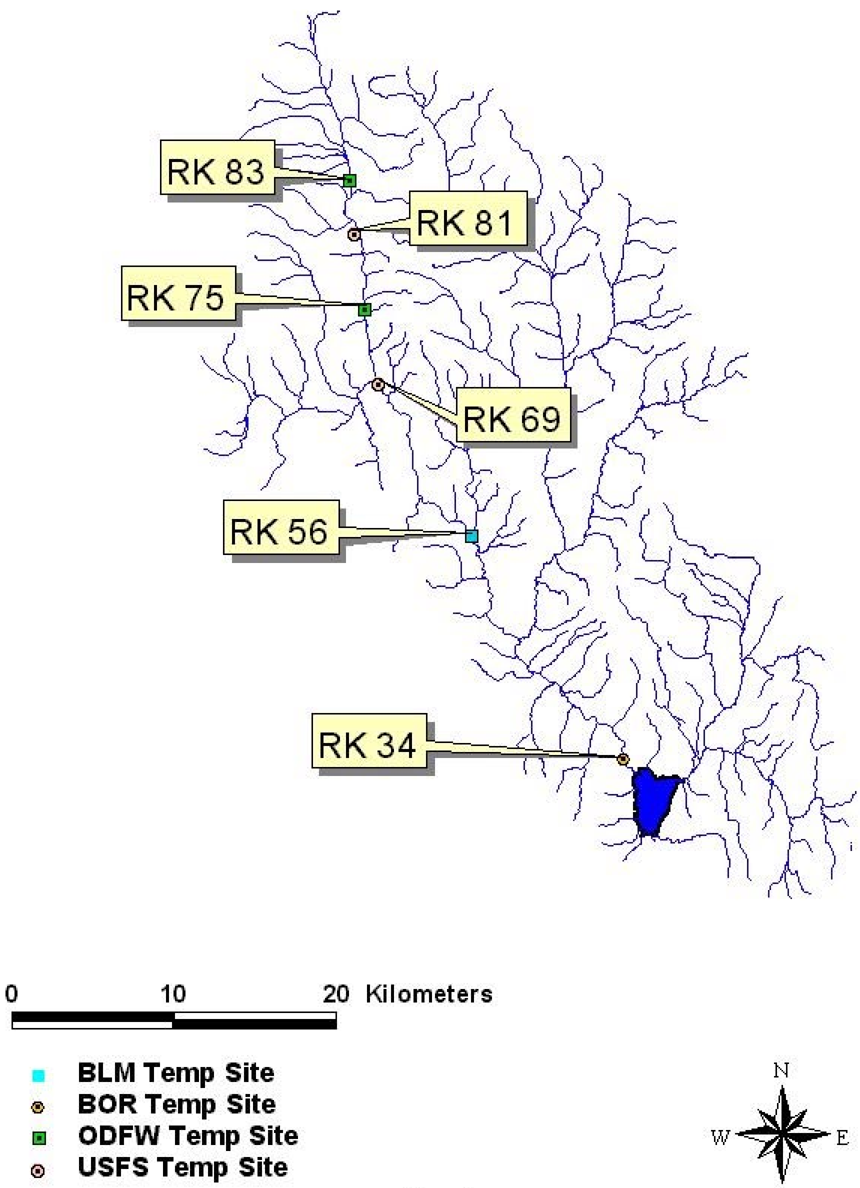

Map 1

# Stream Surveys in Malheur Basin




Map 2

# Temperature Probes




Map 3

# Results

*Habitat Surveys*

ODFW did the analysis on streams surveyed in 1997 and 1998. The Tribe received the analysis in 1999. The seven variables Dambacher and Jones (1997) described as benchmarks for juvenile bull trout habitat and associated values for Summit Creek, Buttermilk Creek, Wolf Creek, and East Fork Wolf are listed in appendix 1. A rank of habitat quality is also provided per reach for each stream.

*Forward Looking Infrared (FLIR) Videography*

The FLIR flights did not define areas of cold-water micro-fugia. Only areas of cold-water output (<17°C) were found near the mouths of the colder tributaries in the upper basin (Map 4). Elk Creek (RK 81) provided cold water to the main stem North Fork Malheur River and Crane Creek provided relatively cooler water (21°C) to the main stem at its confluence with the North Fork Malheur River (RK 70).

*Correlation Between Bull Trout Migration and Stream Temperatures*

Stream temperature is considered water quality limiting for bull trout when maximum stream temperatures exceed 17.8°C during a 7-day period (Buchanan and Gregory, 1997). Using this standard, a rolling seven-day average of maximum temperatures was figured for six temperature site on the North Fork Malheur River.

Site 1 located at RK 33 of the North Fork Malheur had temperatures in 1999 exceed the standard for 55 days (figure 1). Temperatures exceeded the temperature standard on 7/10/99 and did not drop back below the standard until 9/2/99. Site 2 located at RK 56 had similar results compared to site 1. Site 2 had temperatures exceed the 17.8°C standard for 55 days (figure 2). Temperatures exceeded the temperature standard on 7/9/99 and did not drop back below the standard until 9/1/99. Site 3 at RK 69 exceeded the temperature standard for 53 days (figure 3). Site 4 at RK 75 of the North Fork Malheur River has cooler temperature averages, but still exceeded the temperature standard for 44 days (figure 4). Site 5 at RK 81 and site 6 at RK 83 has significant cooling in maximum average temperatures with only 5 days exceeded the standard at site 6 and no days exceeding the standard at site 5 (figure 5 and 6).

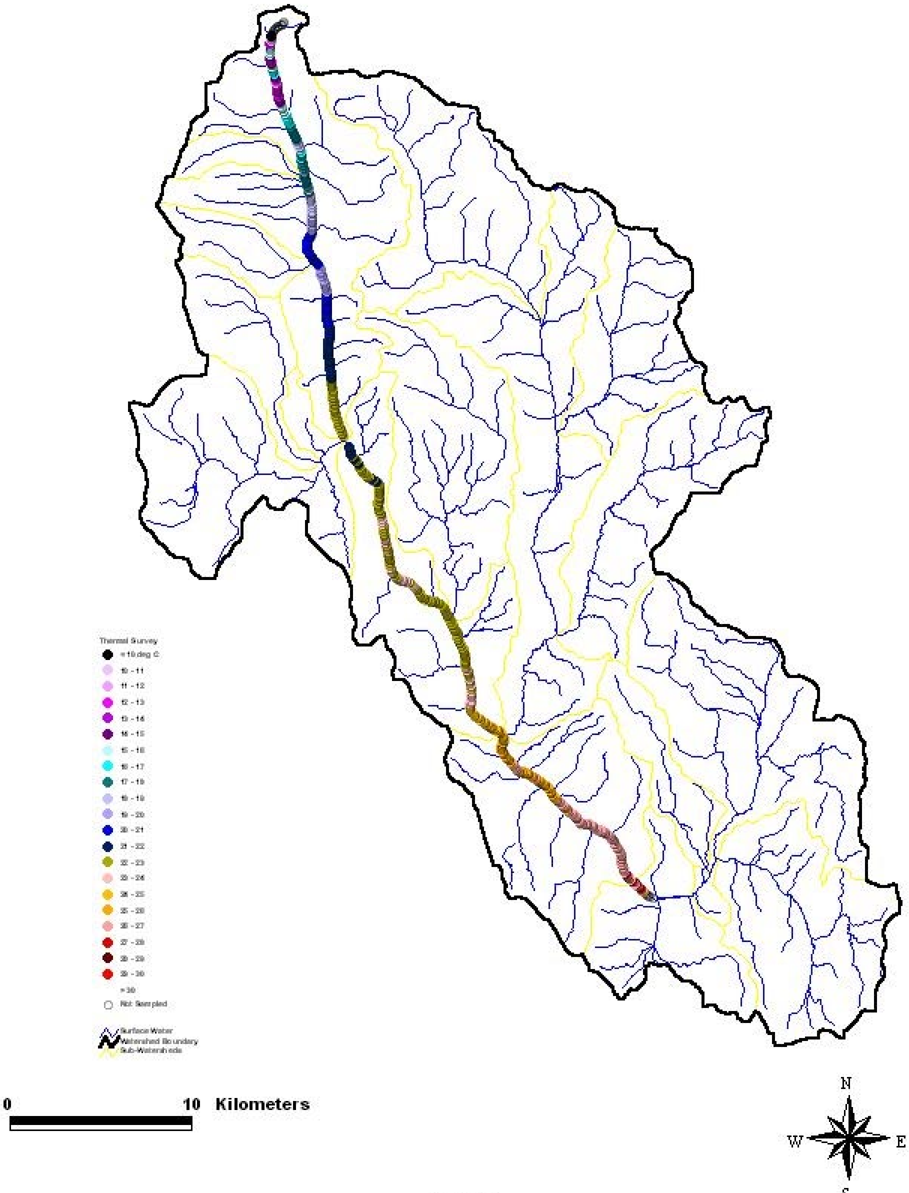
The stream temperature gauge in the North Fork Malheur River below Elk Creek had temperatures that did not exceed the 17.8°C. The cold water flowing out of Elk Creek resulted in cool mainstem stream temperatures. Elk creek has relatively cold water as maximum temperatures did not exceeded 12°C (figure 7). The temperature gauge located in the North Fork Malheur River 2 kilometers above Elk Creek had temperatures that did exceed the 17.8°C standard.

# Discussion

*Habitat Surveys*

Dambacher and Jones(1997) developed benchmarks of habitat quality for juvenile bull trout derived from 59 reaches of 19 Oregon streams from the ODFW habitat survey protocol. The benchmarks of habitat quality developed are listed on table 1. Stream surveys done in 1997 and 1998 were done using ODFW protocol. With streams surveyed with this protocol, we can use the developed benchmarks to determine the quality of habitat for rearing of juvenile bull trout.

# Thermal Survey - NF Malheur




Map 4

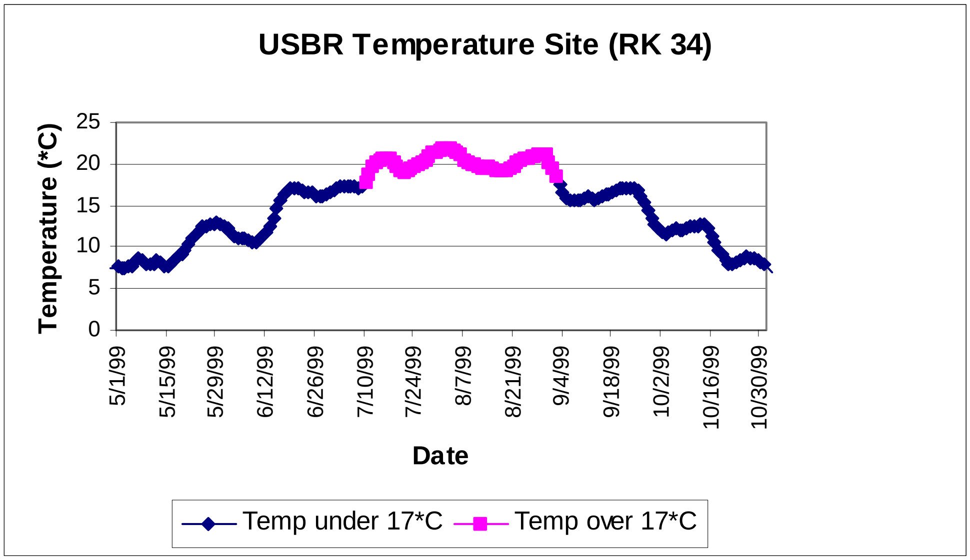



Figure 1 – Stream temperature site located just upstream of Beulah Reservoir. Temperatures are based on a rolling seven day maximum average. Temperatures greater than 17.8°C (64°F) are in pink.

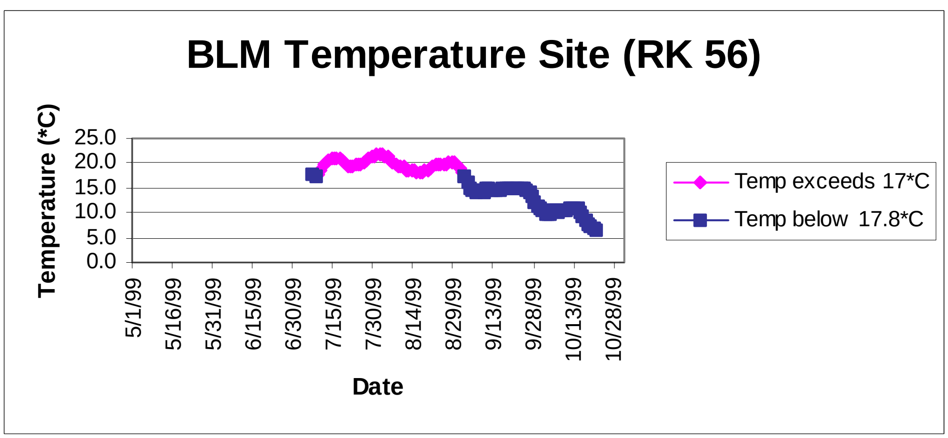



Figure 2 – Stream temperature site located just downstream of Bear Creek. Temperatures are based on a rolling seven day maximum average. Temperatures greater than 17.8°C (64°F) are in pink.

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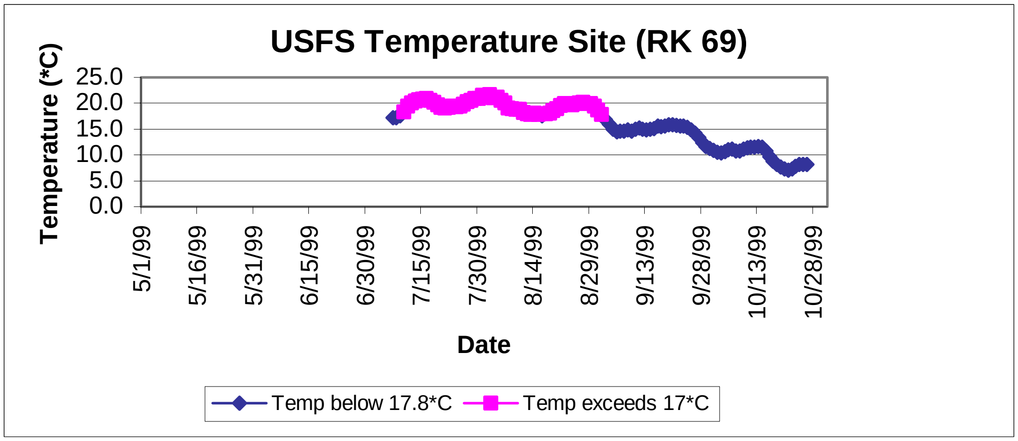


Figure 3 – Stream temperature site located just downstream of Crane Crossing. Temperatures are based on a rolling seven day maximum average. Temperatures greater than 17.8°C (64°F) are in pink

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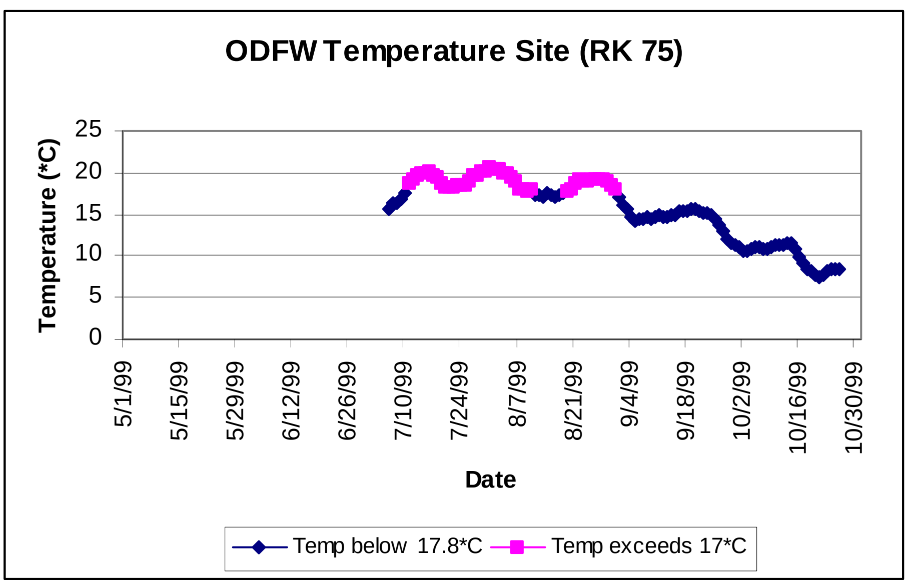


Figure 4 – Stream temperature site located just downstream of North Fork Malheur River trailhead. Temperatures are based on a rolling seven day maximum average. Temperatures greater than 17.8°C (64°F) are in pink.

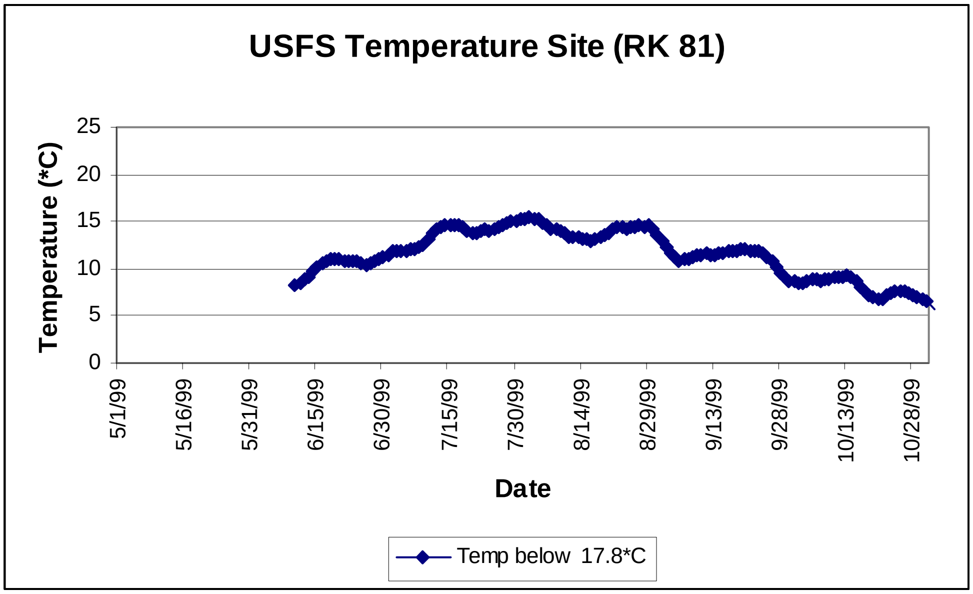


Figure 5 – Stream temperature site located just downstream of Elk Creek. Temperatures are based on a rolling seven day maximum average. Temperatures greater than 17.8°C (64°F) are in pink.

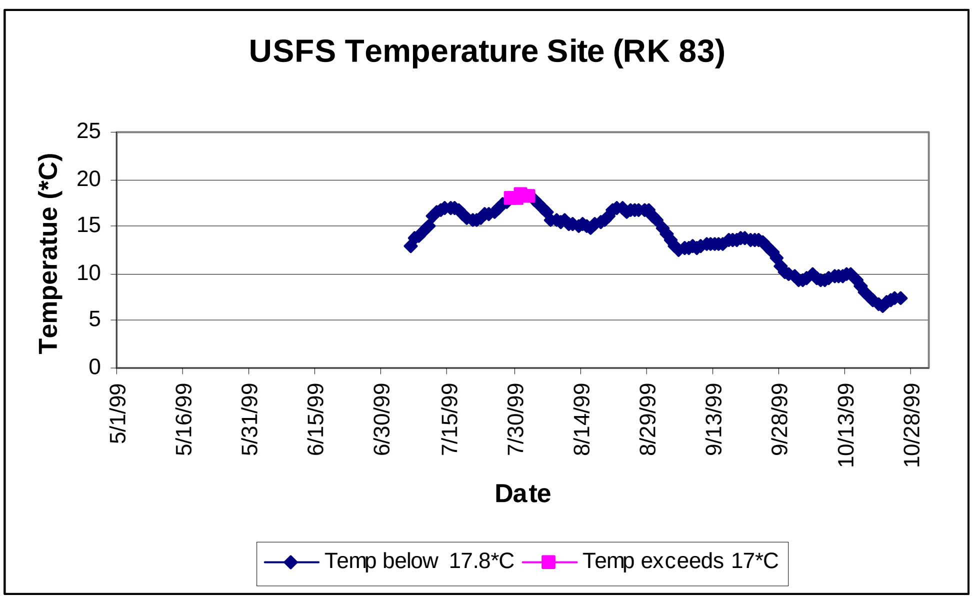


Figure 6 – Stream temperature site located at 16 road bridge. Temperatures are based on a rolling seven day maximum average. Temperatures greater than 17.8°C (64°F) are in pink.

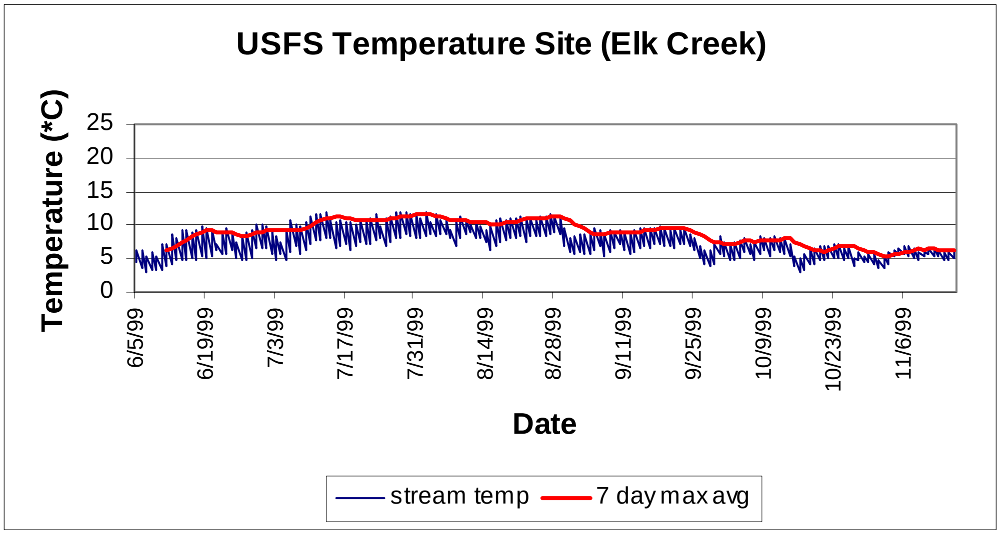


Figure 7 – Stream temperature site located in Elk Creek above the confluence with the North Fork Malheur River. Stream temperatures in blue are hourly temperature readings. Seven day maximum average temperatures are in red.

Buttermilk Creek was surveyed in 1997 and was found to have low quality habitat for juvenile bull trout. The stream lacked large woody debris and had significant bank erosion on the lower reaches that have perennial flow. The deficiency in undercut banks and gravels is common in the drainage. Buttermilk Creek ranges in elevation from 1550 m at the confluence with Crane Creek to 1700 m at its spring source.

**Table 1** – *Benchmarks* of Habitat Quality for Juvenile Bull Trout (Dambacher and Jones,1997).

| Habitat Variable | Low Quality | Moderate Quality | High Quality |
|---|---|---|---|
| Percent shade[1] | <66 | 66 - 87 | >87 |
| Percent riffle gravel[2] | <48 | 48 – 60 | >60 |
| Percent bank erosion[3] | >4 | 0 – 4 | 0 |
| Present undercut bank[3] | <3 | 3 – 11 | >11 |
| Percent riffle fines[2] | >21 | 8 – 21 | <8 |
| LWD pieces / 100m | <10 | 10 – 25 | >25 |
| LWD $m^3$ / 100m | <9 | 9 - 28 | >28 |

[1] Measured with clinometers; percent of 180° that topography or vegetation visually occludes the sky.
[2] Percent wetted area of riffle habitat.
[3] Percent of lineal distance, left and right bank average.

Summit Creek was also surveyed in 1997. Summit Creek had poor overall habitat conditions for juvenile bull trout in respect of shade, bank erosion, riffle substrate, and woody debris. The undercut bank habitat attribute was of good quality throughout the drainage, but active eroding banks were very high in the upper drainage. The headwaters of Summit Creek are at an elevation of 2070 m above sea level.

Wolf Creek was surveyed in 1998. The overall quality of the habitat for juvenile bull trout in Wolf Creek is fair. The lower reaches have the more degraded habitat with low wood counts and shade which can be attributed to roads constructed near the stream and a few active diversions. Otherwise, moderate levels of all habitat attributes dominate the drainage. Dambacher and Jones (1997) found the lower limit of most juvenile bull trout population in Oregon to be less than 1600 m elevation. Elevation of Wolf Creek ranged from 1250 m in reach one and peaked at 1575 m near its spring source. Even if high quality habitat was present throughout the drainage, the low elevation of Wolf Creek is not characteristic of a bull trout stream in Oregon.

East Fork Wolf Creek was also surveyed in 1998. This drainage had significant bank erosion throughout the drainage. Undercut bank habitat was excellent in many reaches of East Fork Wolf Creek. The drainage had the common trend of poor woody debris counts and volume in the lower reaches and excellent counts and volume in the upper reaches. This is due to the increase of lodgepole pine and decrease in ponderosa pine in the upper reaches. East Fork Wolf Creek has an elevation of 1310 m at the confluence with Wolf Creek to 1600 m in the headwaters. The last 2000 m of stream surveyed were dry units. In regards to bull trout production, the low elevation of Wolf Creek drainage is more likely outside the distribution range of producing juvenile bull trout.

Stream surveys only measure physical habitat characteristics and do not include biological and chemical components of the stream. The habitat variables used as benchmarks are not directly linked to bull trout presence, but they characterize important features of juvenile rearing habitat, and collectively describe stream reaches with juvenile bull trout as having healthy riparian zones and undisturbed stream channels (Dambacher and Jones, 1997). To encourage an increase in the distribution of bull trout in the Middle Fork Malheur basin to drainages that currently do not support bull trout, management should determine what activities may have degraded stream habitat in these basins and determine what actions could be done to improve low and moderate quality habitats.

*Forward Looking Infrared (FLIR) Videography*

Cold water seeps may have not been found using FLIR. According to the FLIR data, cold and cool water sources were from tributaries. Cold water (<17$^{o}$C) in the main stem was detected at RK 85 that is near the confluence with Swamp Creek. Though FLIR could not detect areas of cold-water micro refugia, these areas may be present and may provide critical holding habitat for bull trout in the North Fork Malheur River.

*Correlation Between Bull Trout Migration and Stream Temperatures*

Stream temperatures exceeded the 17.8$^{o}$C seven day maximum temperature average standard from RK 34 to RK 75 in early July to late September. Using telemetry data collected in 1999, five radio tagged bull trout were found between RK 69 to RK 75 in temperatures that exceed 17.8$^{o}$C standard. Five radio tagged bull trout on 15 different occasions were found between RK 69 and 75 when temperatures exceed the 17.8$^{o}$C standard (appendix 2).

Assuming the migration rates for radio tagged bull trout are constant between observations, a more defined distribution of radio tagged bull trout can be developed. Bull trout were not present below RK 56 when temperatures exceeded 17.8$^{o}$C standard (figure 8). The later end of the distribution curve of migratory bull trout from RK 56 to RK 69 were present in stream temperatures that exceed the 17.8$^{o}$C standard (figure 9). RK 69 to RK 75 had stream temperatures exceed the 17.8$^{o}$C standard for almost the full distribution of upstream migratory bull trout (figure 10). RK 75 did not have temperatures that exceeded the standard (figure 11 and 12). To conclude, upstream migration of adult bull trout in the North Fork Malheur River are exposed to high stream from river kilometer 56 to 75.

The difference between the daily maximum temperature and daily minimum temperature varied over 10 degrees during peak temperatures in July and August. An analysis of existing temperature sites should be done to determine areas in need of protection and restoration from management activities.

# Acknowledgements

A special thanks is extended to: Wayne Bowers (ODFW) and Allen Mauer (USFS) who worked with the Tribe to coordinate this effort fill in data gaps. Thanks to Mark Tiley (BPT), Newton SkunkCap (BPT), Garrett Sam (BPT), and Jason Fenton (BPT) who spent hours of data collection in the field Bonneville Power Administration provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this research.

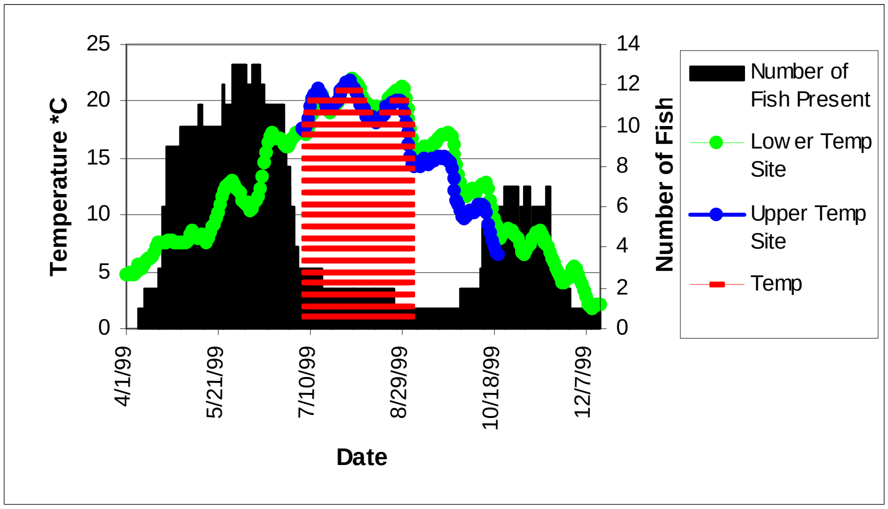


**Figure 8** – Bull trout distribution between the first and second temperature sites (RK 34 and 56) on the North Fork Malheur River. The distribution of bull trout is represented by the bull trout radio tagged in 1999. It is assumed that the bull trout travel at a constant rate between observations. Graph illustrates that radio tagged bull trout left the area before high stream temperatures exceeded the standard for bull trout at 17.8$^{o}$C (Buchanan and Gregory, 1997).

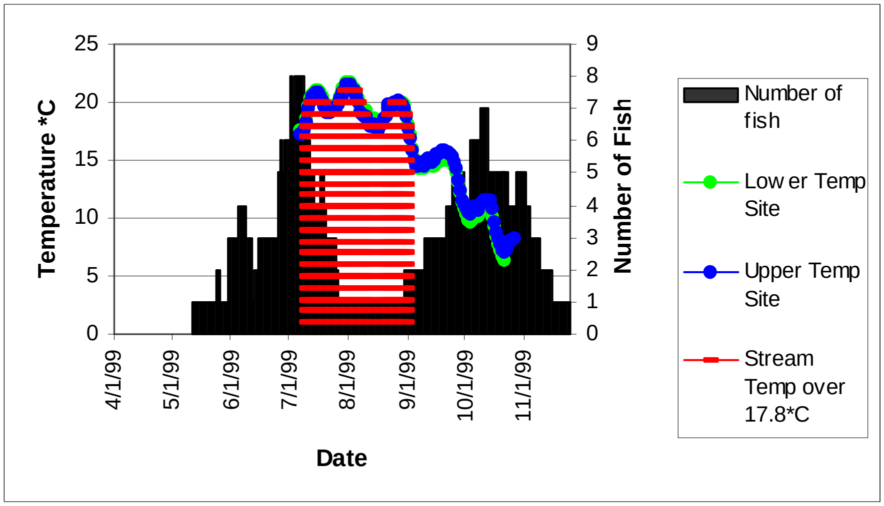


**Figure 9** – Bull trout distribution between the second and third temperature sites (RK 56 and 69) on the North Fork Malheur River. The distribution of bull trout is represented by the bull trout radio tagged in 1999. It is assumed that the bull trout travel at a constant rate between observations. Graph illustrates that radio tagged bull trout were present when stream temperatures exceeded the 17.8$^{o}$C standard (Buchanan and Gregory, 1997). Note that the first peak is upstream migration and the second peak is downstream migration.

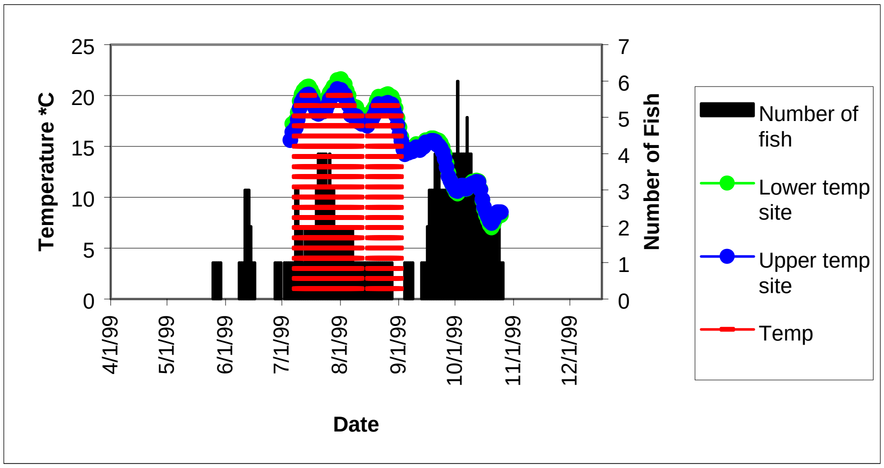


**Figure 10** – Bull trout distribution between the third and fourth temperature sites (RK 69 and 75) on the North Fork Malheur River. The distribution of bull trout is represented by the bull trout radio tagged in 1999. It is assumed that the bull trout travel at a constant rate between observations. Graph illustrates that upstream radio tagged bull trout were present once stream temperatures exceeded the standard of 17.8$^{o}$C (Buchanan and Gregory, 1997).

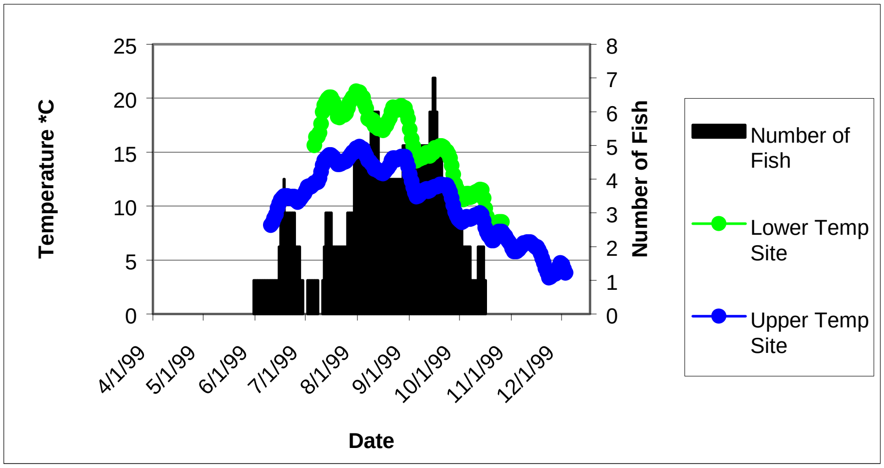


**Figure 11**– Bull trout distribution between the fourth and fifth temperature sites (RK 75 and 81) on the North Fork Malheur River. The distribution of bull trout is represented by the bull trout radio tagged in 1999. It is assumed that the bull trout travel at a constant rate between observations. Temperatures did not exceed the 17.8$^{o}$C standard (Buchanan and Gregory, 1997).

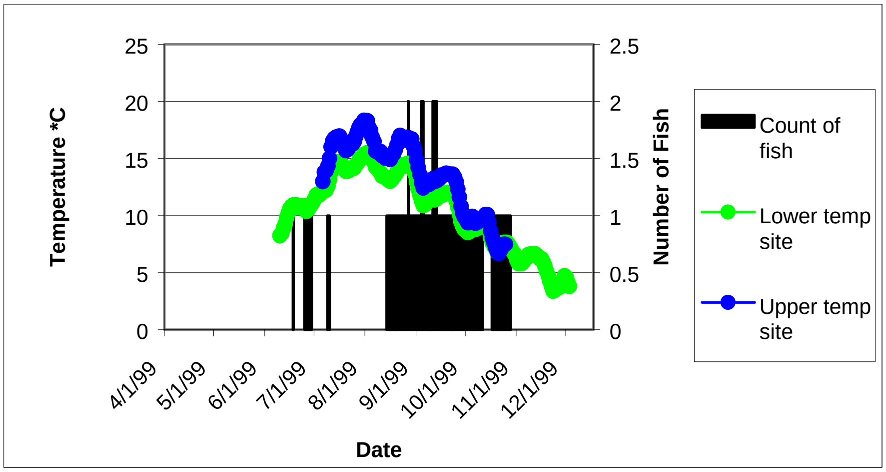


**Figure 12** – Bull trout distribution between the fifth and sixth temperature sites (RK 81 to 83) on the North Fork Malheur River. The distribution of bull trout is represented by the bull trout radio tagged in 1999. It is assumed that the bull trout travel at a constant rate between observations. Temperatures did not exceed the 17.8$^{o}$C standard (Buchanan and Gregory, 1997).

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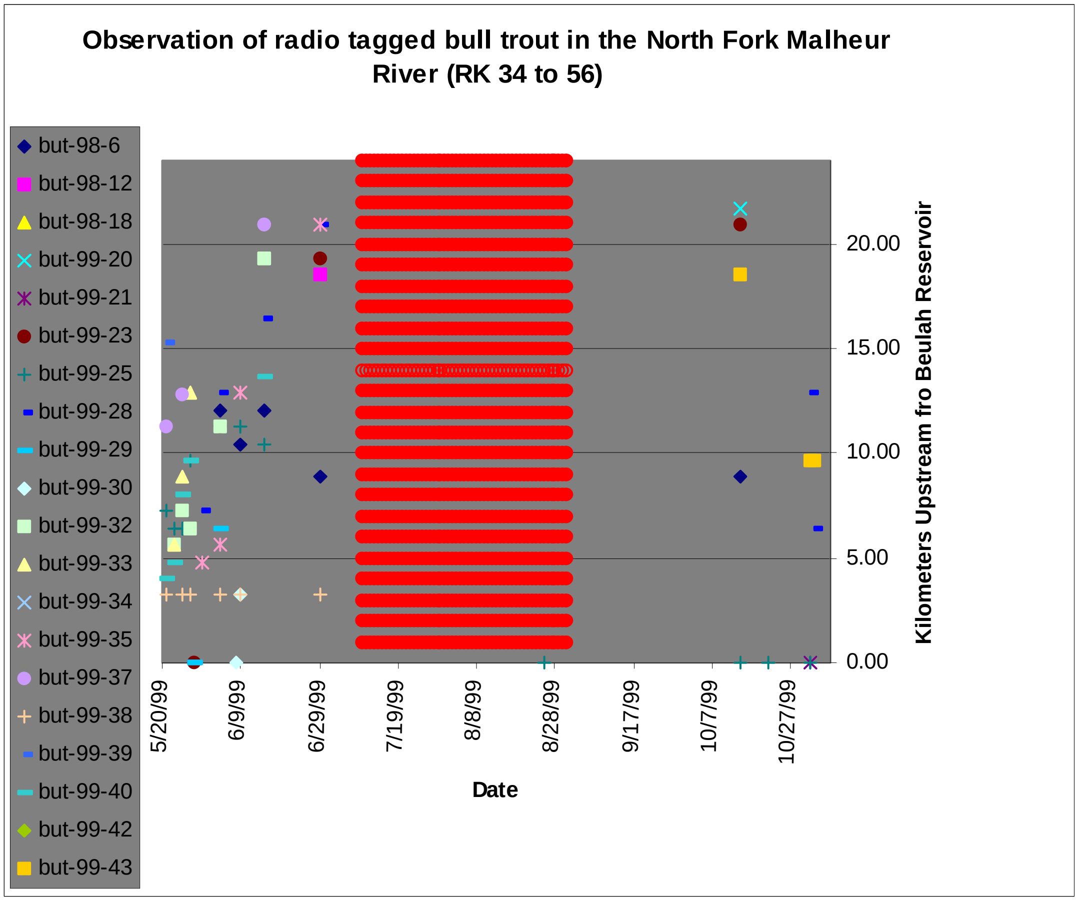
# Appendix 1
# Habitat Quality for Streams Surveyed in 1997 and 1998.

The Tribe used the Oregon Department of Fish and Wildlife's protocol for stream surveys in 1997 and 1998. We sent in the raw data to ODFW in Corvallis for analysis late in 1998. The Tribe received a full report of the analysis in 1999. This appendix uses the habitat benchmarks for juvenile bull trout developed by Dambacher and Jones (1997). Quality of the habitat was ranked as low quality (LQ), moderate quality (MQ), or high quality (HQ).

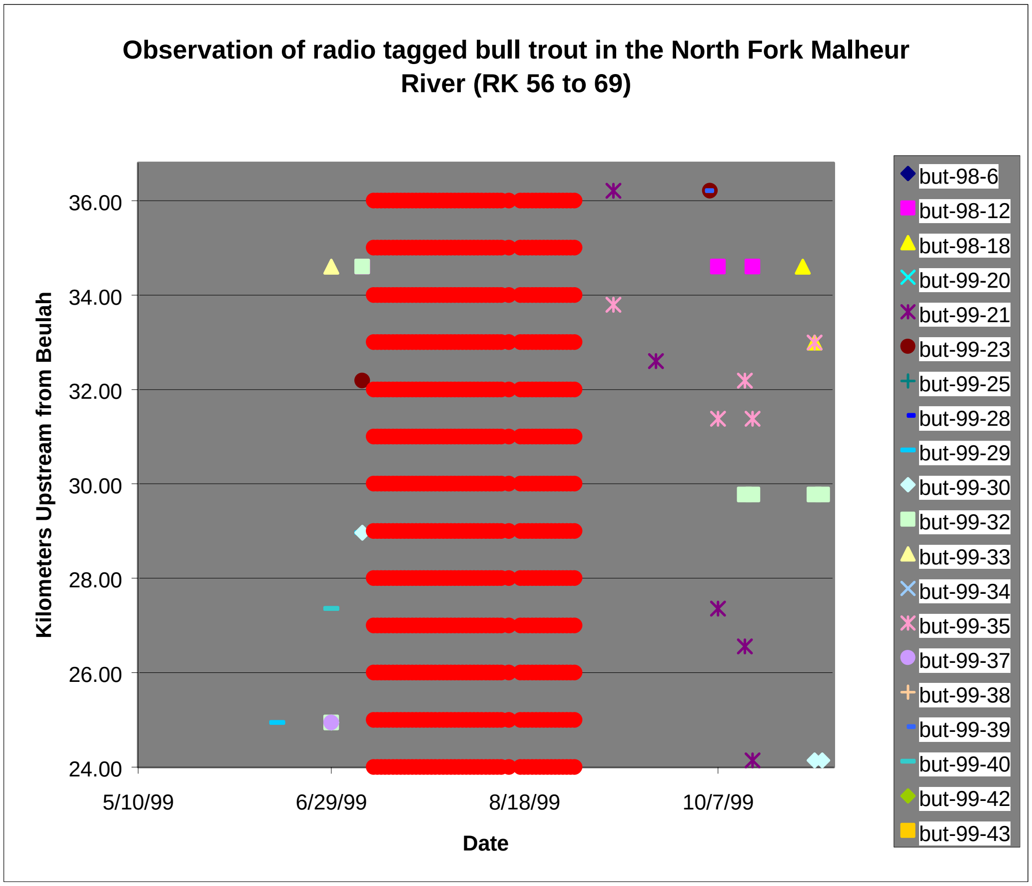
| Stream Name | Reach | Year Surveyed | Percent Shade | Quality Shade | Percent Bank Erosion | Quality Bank | Percent Undercut Bank | Quality Undercut | Percent Riffle Fines | Quality Riffle | LWD pieces per 100 m | Quality LWD count | LWD m3 per 100 m | Quality LWD volume |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wolf | 1 | 1998 | 40 | LQ | 1 | MQ | 3 | MQ | 65 | HQ | 0.2 | LQ | 0.1 | LQ |
| Wolf | 2 | 1998 | 74 | MQ | 3 | MQ | 4 | MQ | 59 | MQ | 1.9 | LQ | 3.4 | LQ |
| Wolf | 3 | 1998 | 72 | MQ | 4 | MQ | 7 | MQ | 77 | HQ | 3.4 | LQ | 8.1 | LQ |
| Wolf | 4 | 1998 | 64 | LQ | 7 | LQ | 5 | MQ | 73 | HQ | 2.2 | LQ | 4.3 | LQ |
| Wolf | 5 | 1998 | 60 | LQ | 4 | MQ | 14 | HQ | 71 | HQ | 1.5 | LQ | 9.1 | MQ |
| Wolf | 6 | 1998 | 75 | MQ | 6 | LQ | 6 | MQ | 79 | HQ | 3.7 | LQ | 9.1 | MQ |
| Wolf | 7 | 1998 | 80 | MQ | 4 | MQ | 4 | MQ | 74 | HQ | 5.6 | LQ | 19.5 | MQ |
| Wolf | 8 | 1998 | 81 | MQ | 1 | MQ | 3 | MQ | 75 | HQ | 6.1 | LQ | 10.4 | MQ |
| Wolf | 9 | 1998 | 84 | MQ | 1 | MQ | 10 | MQ | 83 | HQ | 10.1 | MQ | 18.9 | MQ |
| Wolf | 10 | 1998 | 84 | MQ | 1 | MQ | 13 | HQ | 88 | HQ | 13.1 | MQ | 18.7 | MQ |
| Wolf | 11 | 1998 | 81 | MQ | 0 | HQ | 5 | MQ | 81 | HQ | 18.2 | MQ | 23.3 | MQ |
| Wolf | 12 | 1998 | 73 | MQ | 1 | MQ | 5 | MQ | 80 | HQ | 28.6 | HQ | 25.1 | MQ |
| Wolf | 13 | 1998 | 42 | LQ | 0 | HQ | 1 | LQ | 84 | HQ | 12 | MQ | 11 | MQ |
| Wolf | 14 | 1998 | 77 | MQ | 1 | MQ | 7 | MQ | 72 | HQ | 19.3 | MQ | 13.6 | MQ |
| Wolf | 15 | 1998 | 77 | MQ | 0 | HQ | 4 | MQ | 60 | MQ | 51.3 | HQ | 23.4 | MQ |
| Wolf | 16 | 1998 | 78 | MQ | 0 | HQ | 1 | LQ | 27 | LQ | 17.7 | MQ | 10.7 | MQ |
| Wolf | 17 | 1998 | 78 | MQ | 0 | HQ | 0 | LQ | 4 | LQ | 23.2 | MQ | 18.4 | MQ |

# Appendix 2
# Habitat quality for streams surveyed in 1997 and 1998.

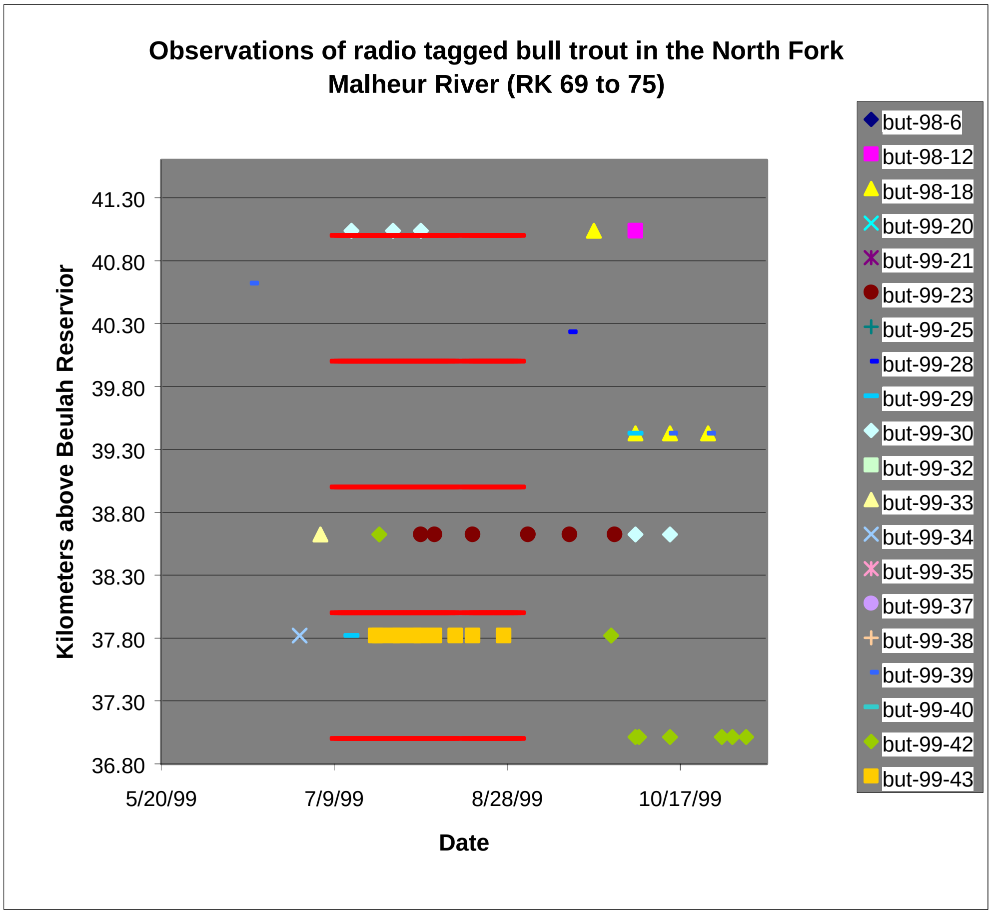
We collected raw data from six temperature probes set in the North Fork Malheur River. With six temperature sites, five reaches can be delineated that have both an upper and lower temperature for each reach. Telemetry data collected for bull trout migration in the North Fork Malheur basin can identify at what time and where radio tagged bull trout were located in the basin. We can correlate their location with these temperature reaches. The red bars on the following graphs represent the time period the 7-day maximum average temperature exceeded 17.8*C.




Graph displays the observations of bull trout between RK 34 to 56. This first reach is about 23 km in length. Lower temperature site is located just above the high water line of Beulah Reservoir. The upper site is located at the mouth of Bear Creek. No fish were observed in this reach once stream temperatures exceeded the 17.8°C standard.




Graph displays the observations of bull trout from RK 56 to 69. This reach is 12 km in length. The lower site is located at the mouth of Bear Creek and the upper site located at Crane Crossing. Fish were not observed in this reach one water temperatures exceeded the 17.8$^{o}$C standard. Several fish were located throughout the reach at the end of June, near the time stream temperatures started to increase above 17.8$^{o}$C. Tracking below Crane Crossing was limited and it is likely some of these fish were present in July when stream temperatures exceed the temperature standard. If additional flights for radio tagged bull trout were done on the first week of July, it is suspected we would of found radio tagged bull trout in this reach.




Radio tagged bull trout that were observed between 5/20/99 to 10/17/99 in the North Fork Malheur River (RK 69 to 75). Fifteen observations and five different radio tagged bull trout were found between 7/9/99 to 9/1/99 when 7-day maximum temperatures exceeded 17$^{o}$C (represented by the red bars).

# Analysis of redband trout migration data collected by rotary screw trap in the North Fork Malheur River, Oregon.

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## Introduction

The redband trout (*Oncorhynchus mykiss gairdneri*) was considered a candidate species for listing under the Federal Endangered Species Act until the March 20, 2000 when the final decision was made not to list redband (United States Fish and Wildlife Service (USFWS), 2000). However, the USFWS decision should not diminish from the need to develop and implement sound redband trout conservation measures. The redband trout is not only an important component of the Malheur National Forest ecosystem, but likely has great significance as a recreational and local economic resource. To adequately design and implement effective conservation policies, a complete understanding of redband life history is essential. The health of the redband population in the Malheur River watershed is currently unknown; thus, an interagency team of biologists representing the Burns Paiute Tribe Fish and Wildlife Department (BPT) Oregon Department of Fish and Wildlife (ODFW) United States Forest Service (USFS) The United States Bureau of Reclamation (USBR) and the Bureau of Land Management (BLM), was formed in 1997. Life history characteristics that were identified as initial research needs can be separated into 6 major categories and are as follows:

1. Identification of the different life history strategies (resident, fluvial, adfluvial).
2. Migratory behavior.
3. Seasonal distribution and abundance.
4. Age-class composition and age structure.
5. Regional differences in the genetic characteristics among Malheur Upper basin Redband populations.
6. The extent of genetic intergression between wild redband trout and stocked hatchery rainbow trout.

The following article discusses the downstream migration of young of year (0 age) and 1+ redband trout captured by rotary screw trap in 1999. Other chapters will discuss categories 2 through 5. Data on distribution and abundance has been discussed for some Malheur North Fork and Middle Fork tributaries in Gonzalez et al. (1998).

## Methods

A 1.52meter (m) (5 foot) diameter rotary screw trap, hence forward referred to as trap, was used to monitor redband trout downstream migration in the North Fork Malheur National Forest, Oregon, from June 02, 1999 to October 19, 1999. The trap was located approximately 460m (1500ft) downstream of Crane Crossing at 0390471E, 4896260N UTM (Universal Transverse Mercator) (see figure 1, overleaf). The trap was installed immediately after Malheur National Forest roads were clear of snow, as the trap had to be transported by vehicle to Crane Crossing. Sampling was terminated on October 19, 1999 due to fluctuations in discharge as a result of over-night freeze-up. The rotary screw section of the trap would strike and catch the stream bottom during the night, causing damage to the trap and affecting the capture efficiency. Several times, early in the morning, the rotary screw trap was found seized on the stream bottom. If the trap was found seized, the fish captured for that sampling period were documented but not included in any analysis, weekly catch totals or calculations.

The trap was situated at the head and middle of a deep scour pool formed by a bottleneck in the North Fork Malheur mainstem channel. The trap was later moved on August 06, 1999 into the center of the thalweg where it remained until sampling was terminated.

Redband weight was measured to the nearest gram (g) and fork lengths (FL) to the nearest millimeter (mm). Redband smaller than 55 mm FL were often too light to register on the Ohaus scale, which ranged from 1g to 1000g. All fish measured, weighed, or sampled for scales and genetic tissue were anesthetized with MS 222 (tricaine methanesulfonate).

Early in June, redband > 50mm FL and <100 mm FL were not measured, but were recorded as 1+ fish. No young of year YOY fish were captured until June 23, 1999. The majority of redband smaller than 40mm FL were not measured and weighed to avoid sampling mortality. No redband smaller than 40mm FL were observed until mid July, more than one month after the first capture of a redband YOY downstream migrant. These fish were assumed to be YOY fish and were recorded as "fry". During late spring and early summer, small subsamples of YOY were periodically measured to monitor increases in length of YOY over time, or determine the range of YOY length. However, samples were either too small or collected too infrequently to provide sufficient data to determine growth. By late summer or early fall, the redband had attained a size that allowed more handling from which point all redband were measured.

From June 07, 1999 until the termination of sampling on October 19, 1999, all 1+ redband were used to determine trap efficiency by fin clipping approximately a 20% portion of the upper caudal fin lobe. Scales were collected from all redband $\geq$ 100 mm FL that were sampled for genetic tissue. As a part of a basin-wide study on the genetic characteristics of Malheur redband trout, some upper caudal fin lobes were clipped and the tissue preserved for genetic analysis. Scales were collected from 5 fish representing a tentative age class. An age class was defined by the assumption that each 50mm FL represented one year of growth. Therefore, a redband 250mm FL was assumed to be 4 years old if captured in the spring or 5 years old if captured in the fall. YOY Redband trout trapping efficiency was determined by taking a small fin-clip on the upper caudal lobe of redband $\geq$ 55mm FL. The efficiency protocol was not initiated on September 10, 1999 for YOY redband because of the small mean size of the fish prior to this date. It was felt that the removal of a portion of the caudal fin from redband < 55mm FL would result in bias towards an artificially higher recapture rate and a high mortality rate as a result of handling and predation. Marked redband were released approximately 460 meters (1500 ft) upstream from the rotary screw trap at the ford crossing once they had recovered from anesthetic. The ford crossing provided shallow pool conditions for released fish to fully recover. Recaptured redband trout were released downstream of the trap.

Temperature was recorded daily with a hand-held mercury thermometer each time the rotary screw trap was checked. A thermograph was deployed by ODFW at Crane Crossing from 07/01/99 to 10/26/99 (Perkins, 2000).

The trap was checked twice daily during spring high-flow conditions to prevent a buildup of debris from causing injury to fish in the live well (fish collection box), and prevent interference with trap operating efficiency. As spring high-flow conditions had subsided by mid June, to a point where debris accumulation was insignificant, the rotary screw trap was checked once daily until August 09, 1999. From August 10, 1999, when fish migration had declined, the trap was checked every one or two days until the termination of sampling on October 19, 1999.

Malheur River North Fork discharge in 1998 and 1999 was monitored by a USBR operated gauging station approximately 0.4km upstream from Beulah Reservoir that provides hourly updates on discharge and temperature. Stream temperature at Crane Crossing was monitored by a thermograph deployed by ODFW. Correlations between YOY and 1+ redband downstream migration with daily maximum stream temperature was performed between July 01, 1999 and August 08, 1999, the period in which daily maximum temperature and daily rotary screw trap checks were measured simultaneously.

All figures were created by Mirosoft Excel 97 as were all statistical analysis. Trap efficiency was calculated using the procedure described in Seelbach (1985) and Roper and Scarnecchia (1996). The total number of redband trout that passed by the rotary screw trap was calculated using the over-all trap efficiency as described in Roper and Scarnecchia (1999). 95% confidence intervals (CI) were calculated using the formula for the variance of a proportion which is as follows: $p$ = +/- Z $_{\alpha/2}$ square root ($pq/N$ ) where p = proportion, q =1-p, N = sample size (Kennen et al. 1994). All word processing was performed in Micorsoft Word 97. A 1999 Discharge graph was provided by the USBR and was presented in Tiley, 2000a as figure 6.

# Results

A Length frequency distribution was used to distinguish between young of year (YOY) and 1+ redband trout (See figure 1). Redband $\geq$ 55 mm FL from June up to August 01 were considered 1+ and are not included in figure 1. Redband < 55 mm FL captured from June 02 to August 01 were considered YOY. Redband $\leq$ 90mm FL captured from August 02 to the end of the sampling period were considered YOY. Redband > 90mm FL captured after August 02 were assumed to be 1+ years of age.

The length-weight relationship for North Fork Malheur redband captured by rotary screw trap was $0.000005x^{3.1515}$ (see figure 2). The $R^2$ value of 0.9665 indicated a very close relationship between redband length and weight whereby 97% if the variation in weight can be explained by length.

Age 1+ rainbow trout were most prominent in the screw trap data in early June, gradually declining as flows subsided (see figure 3) suggesting that at least one cohort of redband overwintered 1+ in upstream tributaries. Two large redband, one 438mm FL captured on June 03, 1999 and one 358mm FL captured on June 05, 1999 were likely post spawn fluvial or adfluvial adults. No redband trout were captured between the lengths 272mm FL and 358mm FL. Genetic tissue samples were collected from these two fish to determine with certainty whether they were pure-strain native redband trout, of hatchery origin, or a hybrid of both wild and hatchery origin. Redband genetic samples collected in 1999 had not yet been analyzed by the time this report was written.

**Table 1.** Week numbers and corresponding dates indicating rotary screw trap weekly sampling period.

| Week # | Dates | Week # | Dates | Week # | Dates | Week # | Dates |
|---|---|---|---|---|---|---|---|
| 1 | 06/03-06/09 | 6 | 07/08-07/14 | 11 | 08/12-08/18 | 16 | 09/16-09/22 |
| 2 | 06/10-06/16 | 7 | 07/15-07/21 | 12 | 08/19-08/25 | 17 | 09/23-09/29 |
| 3 | 06/17-06/23 | 8 | 07/22-07/28 | 13 | 08/26-09/01 | 18 | 09/30-10/06 |
| 4 | 06/24-06/30 | 9 | 07/29-08/04 | 14 | 09/02-09/08 | 19 | 10/07-10/13 |
| 5 | 07/01-07/07 | 10 | 08/05-08/11 | 15 | 09/09-09/15 | 20 | 10/14-10/19 |

Redband 1+ capture frequency slightly increased each week between weeks 9 and 13 and again between weeks 17 and 19. There did not appear to be a trend between temperature recorded at Crane Crossing or flow with the later two peeks (see figure 6 in Tiley, 2000a).

YOY redband however showed a strong bimodal downstream migration pattern during the sampling period. The first YOY was captured on June 23, 1999 (week 3), the only YOY redband captured that week, rapidly increasing to 197 YOY captured during week 6. Redband YOY capture rate declined rapidly from 197 during week 6 to 9 YOY captured during week 9.

Following the sharp decline in YOY redband capture rate, week 10 to week 13 saw a rapid resurgence in YOY redband catch rate from the 9 YOY captured during week 9 to 142 YOY captured during week 13. Weekly catch rates remained relatively high at over 100 YOY/week until the screw trap was removed on October 19, 2000.

Of the 450 YOY redband marked, 82 were recaptured providing a trap efficiency of 18%. Of the 371 1+ redband marked, 53 were recaptured providing a trap efficiency of 14% (see table 1).

Estimates for the number of YOY and 1+ redband that passed by the screw trap was calculated using the following equation: **Total # unmarked fish/capture efficiency.** The estimate for the number of YOY redband that passed downstream of the trap between September 10, 1999 and October 19, 1999, was 2470 individuals (range = 2246 –2744, 95% CI). The estimate for the number of 1+ redband that passed downstream of the trap was 2597 individuals (range = 2297-2988, 95% CI). See Table 2.

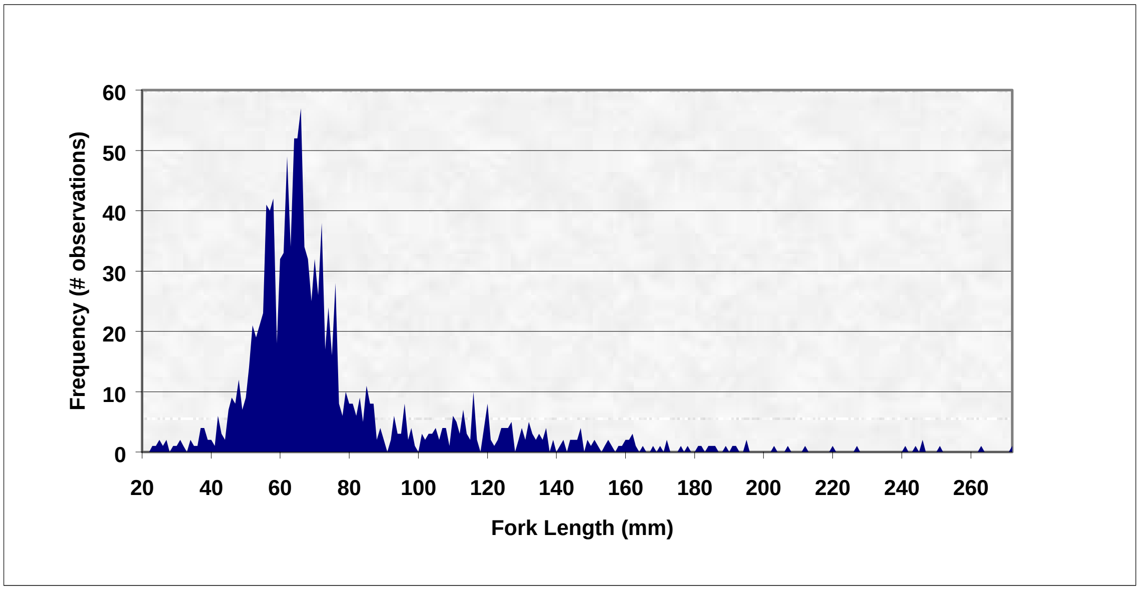


**Figure 1.** Length-frequency distribution of redband trout captured by rotary screw trap, Crane Crossing, North Fork Malheur River, June 03, 1999 to October 19, 1999.

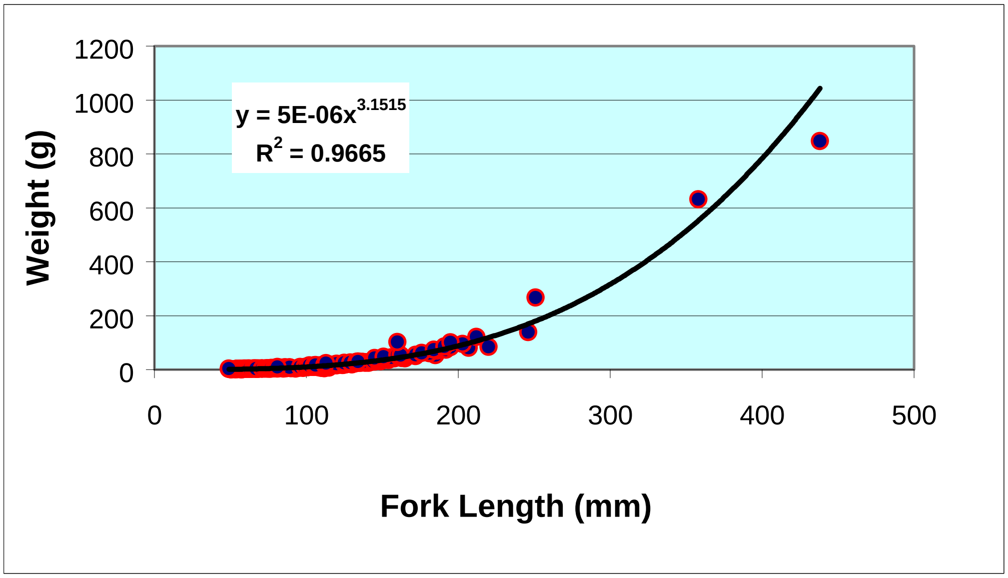


**Figure 2.** Length-weight relationship of Malheur River redband trout captured by rotary screw trap, 6/3/99-10/19/99, Crane Creek.

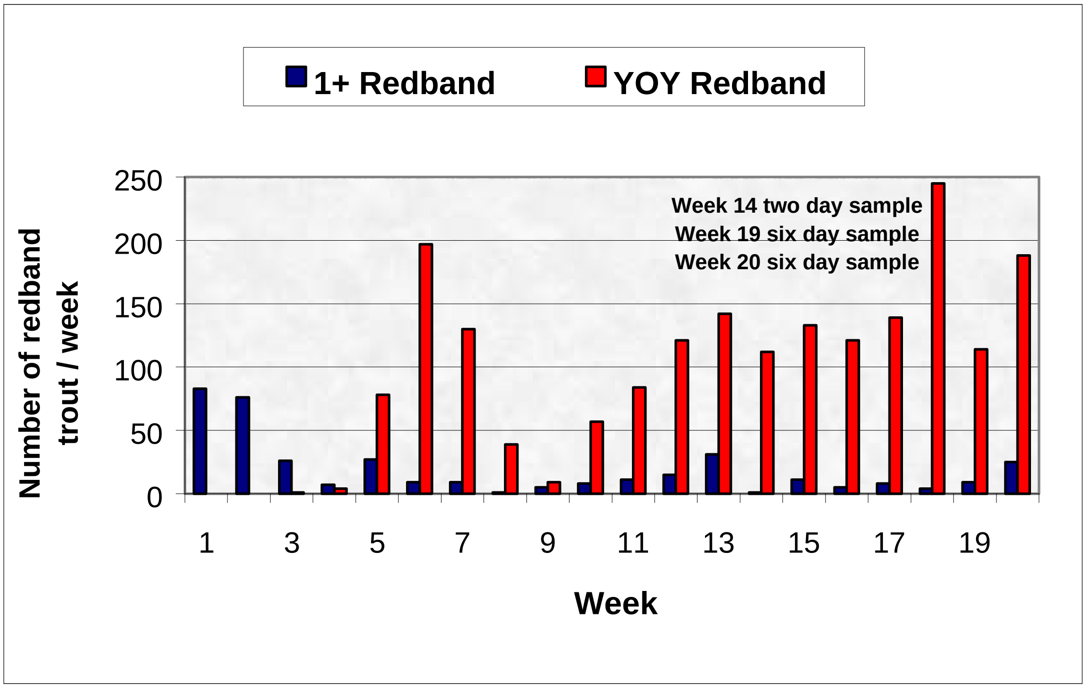


**Figure 3.** Number of redband trout captured by rotary screw trap per week between June 03, 1999 and September 19, 1999, Crane Crossing, North Fork Malheur River, Oregon.

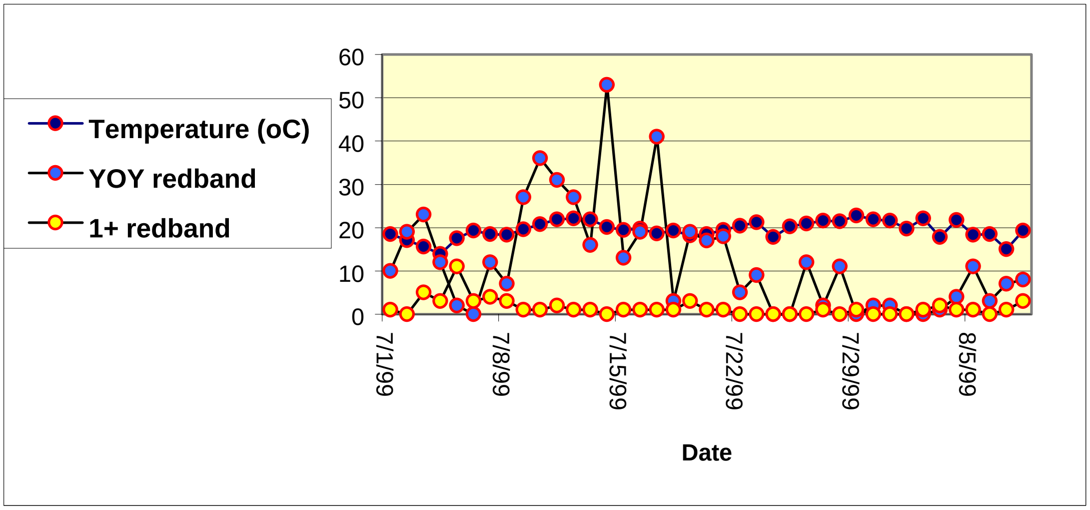


**Figure 4.** Redband YOY and 1+ capture rate collected by rotary screw trap in relation to ODFW temperature logger data (Perkins, 2000) collected from July 01, 1999 to August 08, 1999 at Crane Crossing, North Fork Malheur River.

**Table 2.** Number of marked and recaptured redband YOY and 1+ redband trout and respective trapping efficiencies captured by 1.52m diameter rotary screw trap. Trap efficiency data was obtained for redband YOY between September 10, 1999 and October 19, 1999, and 1+ redband between June 02, 1999 and October 19, 1999.

| Redband Age Class | # Marked and released upstream | # Recaptured | Percent Recaptured (Trapping Efficiency) |
|---|---|---|---|
| YOY Redband | 450 | 82 | 18 |
| 1+ Redband | 371 | 53 | 14 |

**Table 3.** Estimates and confidence intervals for the number of redband YOY captured by 1.52m diameter rotary screw trap between September 10, 1999 and October 19, 1999, and 1+ redband captured between June 02, 1999 and October 19, 1999.

| Age Class | YOY | 1+ |
|---|---|---|
| **95% CI** | +/- 1.8201% | +/- 1.816731% |
| **Estimate** | 2470 (2246-2744) | 2597 (2297-2988) |

During the decline in capture rate, from July 08, 1999 to August 04, 1999, maximum daily stream temperatures exceeded 20°C and consistently exceeded 22°C (See figure 4). However, stream temperature and downstream YOY redband migration was not correlated between July 1, 1999 and August 08, 1999(correlation coefficient = -0.023, $R^2$= 0.0005, p>0.05). 1+ redband downstream migration was significant and inversely correlated to maximum daily stream temperature (correlation coefficient = -0.398, $R^2$ = 0.158, p<0.05).

## Discussion

Both the length-frequency graph (figure 1) and the weekly capture rate graph (figure 2) illustrate how the catch composition was dominated by YOY redband. The larger 1+ redband probably avoided capture more easily than YOY redband. The absence of redband between 272mm FL and 358mm FL suggests a separation in life history between the fluvial (<275mm FL) and adfluvial redband (> 300mm FL). The two large fish, 358mm FL and 458mm FL, were probably adfluvial. Based on the BPT redband angling data and personal discussions with recreational fishermen from late June to early November, redband larger that 250mm FL are rare in the North Fork Malheur River upstream of Crane Crossing, suggesting that fluvial forms of redband seldom reach lengths in excess of 250 mm FL. Resident fish would not be represented in the trap data, as resident forms remain in their natal tributaries throughout their lives. However, since the age at maturity is not known for either the fluvial and adfluvial redband, or the ages and sizes of outmigrating adfluvial redband, all 1+ fish captured in the trap could be either fluvial or adfluvial forms. Future scale analysis will provide the length-at-age data needed to distinguish between fluvial and adfluvial North Fork Malheur redband trout.

Trapping efficiency estimates for YOY and 1+ redband at 18% and 14% respectively were similar to that observed for bull trout at 13% despite large differences in sample sizes (n=52 for bull trout) (Tiley, 2000a). However, because of the differences in sample sizes, confidence intervals at 95% were noticeably smaller for redband at 1.8 % compared to 5% for bull trout. Some of the age 1+ redband may not have been migratory, and may have been captured multiple times. If so, this would have artificially increased trap efficiency resulting in an underestimate of the number of 1+ redband that passed downstream of the trap.

Trap efficiencies are not available for redband YOY prior to September 10, 1999 because of the limited man-hours available, and to avoid sampling bias that might be caused by fin-clipping the smaller

YOY redband, making them artificially more susceptible to recapture. Alternative marking techniques such as tattooing might enable researchers to obtain trap efficiency estimates that would not be limited by fish size. Fin-clipping the YOY redband >55mm FL may still have increased their probability of being recaptured. If so, the number of downstream migrating YOY redband would have been underestimated.

Roper and Scarnecchia (1999) observed temperature to be a key influence on chinook salmon (*O. tshawytscha*) smolt outmigration timing. Thedinga et al. 1994 also observed a downstream biomodal migration pattern in an Alaskan population of steelhead (*O. mykiss*) smolts. The high stream temperatures observed during weeks 8 to 11 (July 15, 1999 to August 04, 1999) coincides with rapid decline in weekly capture rate from 197 redband/week to 9/week over a period of 3 weeks. However, differences in downstream migration timing and duration may vary from population to population depending on local variation in environmental factors such as discharge, site specific variation in temperate, prey availability, and inherent genetic factors that are not yet well understood (Markle, personal communication).

The low $R^2$ value = 0.158 indicated that factors other than daily maximum stream temperture affected 1+ redband downstream migration. The USBR discharge graph (see Tiley, 2000a, figure 6) and 1+ downstream migration in June suggested a probable significant correlation between discharge and redband 1+ downstream migration. Factors found to affect salmonid downstream migration are mentioned in (Tiley, 2000a).

The trap results on redband are consistent with what is thus far known about the North Fork Malheur River populations: that redband spawn in mid to late spring (Perkins, personal communication). Based on the assumption that YOY redband emerge from gravels after approximately six weeks from fertilization (Perkins, personal communication) the majority of fluvial and adfluvial redband probably spawned between early May and early June in 1999 since peak downstream migration of recently emerged redband (approximately 25mm FL) occurred in early to mid July. Since the natal tributary stream, and the distance and duration traveled by the YOY redband captured in July is unknown, the exact time of the peak fluvial and adfluvial redband spawning period is unknown.

Captured bull trout, and possibly the larger (> 150mm FL) redband trout, probably consumed some of the smaller redband trout while in the live well. Predation must therefore be considered a potential source of error. Whether this error was significant cannot be determined with the data collected. Future downstream migration studies involving a rotary screw trap should consider modifying the live well to eliminate predation as a potential source of sampling error.

The inconsistency in weekly effort, particularly during week 14 (2 day sample), clouds the results, making it difficult to compare weeks 19 and 20 and especially week 14 with the other sampled weeks. A mean daily catch rate was calculated by dividing the number of redband trout captured by the number of days sampled for a given week. Sample variance for a given week could not be calculated for some of the later part of the sampling period because of the variation in time between trap checks (1 or 2 day periods between trap checks). Variation in time between trap checks was the main reason why the data was analyzed for weekly instead of daily catch rates. Due to the lack of sample variability data, it is difficult to make inferences about redband downstream migration behavior at a daily scale.

## Acknowledgements

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